AN INVESTIGATION OF BUILDING INFORMATION MODELING MATURITY IN TURKISH SMALL-MEDIUM SIZE ENTERPRISES ARCHITECTURAL AND ENGINEERING FIRMS

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ABSTRACT

AN INVESTIGATION OF BUILDING INFORMATION MODELING MATURITY IN TURKISH SMALL-MEDIUM SIZE ENTERPRISES ARCHITECTURAL AND ENGINEERING FIRMS

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Architecture, Engineering and Construction (AEC) industry experiences Building Information Modeling (BIM) transition process in all over the world. As the firms have advanced on BIM implementation, a necessity to benchmark the BIM performance has emerged. A couple of assessment tools were released for the sector to be used by organizations, individuals and governments to benchmark the BIM implementation maturity. The architecture and engineering firms in Turkey are also in the midst of BIM transition. However, there is little attention given to studies related with BIM maturity assessment in Turkish AEC organizations. For that reason, a BIM maturity assessment study was conducted in Turkey with seven architecture and engineering firms. The findings of the assessment study stated that the sector suffers from a lack of available official guidance and documentation on BIM implementation. In order to understand the practical handicap of the issue, the best practice guides of United States and United Kingdom were compared with Turkish practices. Based on the derived information from this comparison study, an evaluation and discussion session followed the process. At the end of the research, the findings were not only validated by comparing the results with the statements of

the firms that participated in BIM maturity assessment but also has been echoed with the statements in the sector report in the 10th Development Plan of Turkey released in 2013 by the Ministry of Development.

Keywords: BIM, BIM Transition, BIM Implementation, BIM Maturity, Organizational Assessment

ÖZ

TÜRKİYE'DE KÜÇÜK VE ORTA ÖLÇEKLİ İŞLETME BÜYÜKLÜĞÜNDEKİ MİMARLIK VE MÜHENDİSLİK FİRMALARINDA YAPI BİLGİ MODELLEMESİ OLGUNLUĞU ÜZERİNE BİR ARAŞTIRMA

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Dünya genelinde Mimarlık, Mühendislik ve İnşaat (MMİ) endüstrisi Yapı Bilgi Modellemesine (YBM) geçiş sürecini deneyimlemektedir. Firmalar YBM kullanımı konusunda uzmanlaştıkça, YBM olgunluğunun, hükümetler, organizasyonlar ve kullanıcılar tarafından tespiti ve değerlendirilmesi ihtiyacı ortaya çıkmıştır. Sektördeki bu ihtiyacı karşılamak adına bir takım değerlendirme araçları kullanıma sunulmuştur. Türkiye'de de mimarlık ve mühendislik firmaları YBM'ye geçiş yapmaktadır. Fakat akademik çalışmalarda Türkiye'deki MMİ sektörü firmalarındaki YBM olgunluğu üzerine yeteri kadar odaklanılmamıştır. Bu konudaki eksikliği kapatmak adına bu çalışmada yedi mimarlık ve mühendislik firmasıyla YBM olgunluğu değerlendirmesi yapılmıştır. Bu değerlendirme çalışması sektörde resmi YBM uygulama yönergesi eksikliği olduğunu ortaya çıkarmıştır. Bu resmi YBM dokümanı eksikliğinin pratikte ne tür engeller

oluşturduğunu anlamak için Amerika ve İngiltere'deki en iyi kullanım dokümanları ile Türkiye'deki resmi hizmet belgeleri kıyaslanmıştır. Bu kıyaslama tablosundan elde edilen veriler daha sonra değerlendirilmiş ve tartışılmıştır. Elde edilen sonuçlar hem YBM olgunluğu değerlendirmesine katılan firmalardan elde edilen verilerle hem de Kalkınma Bakanlığı'nın 2013 yılında yayınlamış olduğu 10. Kalkınma Planı'nda yer alan Teknik Müşavirlik alanındaki sektör raporlarıyla desteklenerek geçerlilik kazandırılmıştır.

Anahtar Kelimeler: YBM, YBM'ye geçiş, YBM Uygulamaları, YBM olgunluğu, Örgütsel Değerlendirme

To my beloved wife ÖZDEN and my daughter MERYEM

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LIST OF SYMBOLS AND ABBREVIATIONS

AEC	Architecture, Engineering and Construction
AIA	American Institute of Architects
BIM	Building Information Modeling
CAT	Chamber of Architects of Turkey
CIC	Construction Industry Council
CMM	Capability Maturity Model
IPD	Integrated Project Delivery
IU	Indiana University
KOBİ	Küçük ve Orta Büyüklükteki İşletmeler
KPIs	Key Performance Indicators
MMİ	Mimarlık, Mühendislik ve İnşaat
NBIMS	National Building Information Modeling Standard
NBIMS-US	National Building Information Modeling Standard-United States
SME	Small-Medium Enterprises
TNO	Original Explanation: Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek. English: Netherlands Organization for Applied Scientific Research
3D	3 Dimension
2D	2 Dimension
YBM	Yapı Bilgi Modellemesi

CHAPTER 1

1 INTRODUCTION

Architecture, Engineering and Construction (AEC) industry experience Building Information Modeling (BIM) transition process in all over the world (Kassem, Succar, & Dawood, 2013; McGraw-Hill, 2012). BIM is an expanding collection of concepts and tools which have been attributed with transformative capabilities (Succar, 2010) in which the changes starting from early phases of design to decommissioning phases of project life-cycle.

Considering the failures, deficiencies and defects in design, construction and operation phases of building projects that AEC industry suffer from, BIM provides various advantages to the project participants (Azhar, 2011; Bryde, Broquetas, & Volm, 2013; Eastman, Sacks, & Liston, 2008; Jernigan, 2007; Masood, Kharal, & Nasir, 2014; Meadati, Irizarry, & Akhnoukh, 2011; Migilinskas, Popov, Juocevicius, & Ustinovichius, 2013; Smith & Tardif, 2009; Wong, Wong, & Nadeem, 2009). As a result of this fact, there is a continuous spread of BIM adoption in the world (McGraw-Hill, 2012).

BIM enables increased communication, collaborative working practices, and interoperability options and so far for the building industry. However, these new terms and applications are not familiar terms and applications in traditional working practices. Not like transition of hand drawing working method to digital drawing practices once experienced when the computers are getting more involved, BIM adoption necessitate comprehensive study to go on. This is due to fact that, BIM is

changing not only the available working applications but also the way of practices and approaches.

Various business interactions, project delivery methods, workflows and processes in the AEC industry practices makes it a challenging issue for developing metrics and criteria for assessing BIM implementation (Smith & Tardif, 2009). The expansion of BIM adoption coincides with the increased research on BIM implementation in order to detect and measure BIM implementation in an organization (Smith & Tardif, 2009). In most countries, BIM adoption is systematized and in order to further research and develop the process, BIM adoption metrics are described and BIM maturity assessment tools are presented (Barlish & Sullivan, 2012; Chen, Dib, & Cox, 2014; Giel & Issa, 2013; Jung & Lee, 2015; Kam, Senaratna, Xiao, & McKinney, 2013; NBIMS, 2007; Sebastian & Berlo, 2010; Smith & Tardif, 2009; Succar, 2010). According to the results of these assessment tools, research and development studies are maintained to increase the efficiency of BIM adoption.

The necessity of BIM implementation and tendency of the technical consultancy firms to BIM adoption in the coming future are mentioned in governmental reports in Turkey (TCKB, 2013; TMMMB, 2015). Like other countries, design firms in Turkey are experiencing BIM adoption and there has been already released a number of research studies conducted so far including various aspects of BIM and BIM implementation in Turkish AEC industry.

Akgun (2016) Gercek (2016), Oktem (2016), Kopuz (2015), Karahan (2015), Akkoyunlu, (2015) and Salah (2015) focused on various aspects of BIM implementation in Turkey while, Doser (2016) proposed appropriate BIM working models for Turkish mass housing industry. Savaskan (2015) and Sow (2016) pay attention to energy efficiency and sustainability studies whereas Ezcan *et al* (2013) investigated the BIM gap in terms of awareness and use of BIM in construction

sector by comparing the survey results of Turkey with UK market. The list of these studies are presented in Table 1. These studies unveiling the fact that, although there have already been studies related with BIM adoption and implementation, there is still a gap in the research of BIM implementation performance benchmarking in Turkey. Therefore, it is the research focus of this study to collect and transfer BIM performance benchmarking data from Turkish construction sector to the literature.

Table 1. The List of the researches conducted in Turkey published until 2017. Source: Council of Higher Education Thesis Center

Reference	**Research Area**
(Sow, 2016)	The study focuses on sustainability analysis model proposal for Doha.
(Gercek, 2016)	By reviewing BIM implementation standards and guides released in different countries, the study was aimed to help the construction firms during the implementation of BIM in construction phase of projects. By taking a case study of a large construction firm's quantity take off and cost estimation studies in Turkey, the study argued the unique challenges of BIM implementation in Turkish AEC industry
(Alkawi, 2016)	The study give credit to take benefits from interdisciplinary working environment of BIM by proposing a T-model education model during the education of architecture student.
(Akgun, 2016)	The study examines the progress payment applications in contractor firms and the use of BIM technology in progress payment process.
(Doser, 2016)	The study focus on integration of BIM to facility management. By proposing a model consisting of BIM promises, new workflow was compared with traditional workflow.
(Oktem, 2016)	Considering the needs of Turkish AEC industry practitioners in terms of BIM implementation, the study establishes a BIM implementation framework to help the firms newly started to adopt BIM concept.
(Muratoglu, 2015)	The study investigates the contribution of BIM on design phase related disputes in traditional project delivery methods (Design-Bid-Build).
(KOPUZ, 2015)	The study aimed to find out necessary items and terms that a BIM protocol shall include in order to efficiently implement BIM practices.

Table 1. *Continuing*

(Karahan, 2015)	The study investigates the critical success factors of Turkish Construction Sector firms on efficiently implement BIM practices.
(Akkoyunlu, 2015)	By analyzing available BIM execution plan had already prepared and utilized, an appropriate BIM execution plan is selected and applied in a Turkish mass housing construction project.
(Savaskan, 2015)	By mentioning necessity to application of energy efficiency in both public and private sector buildings in Turkey, the study proposed a prototype BIM model to be applied in energy efficient buildings to evaluate the potentials of utilizing open-source BIM based models on energy efficiency calculations.
(Salah, 2014)	The study investigate the strong and weak sides of 4 D modelling software utilization in construction projects.
(Akkaya, 2012)	The study investigate the usage potentials of BIM in Turkish construction sector and then applying BIM on reduction and prevention of waste-concrete during the construction phase.
(Ezcan, Goulding, Kuruoglu, & Leilabadi, 2013)	The study investigate the BIM gap in terms of awareness and use of BIM in construction sector by comparing the survey results of Turkey with UK market.

1.1 Problem Statement

Construction sector is directly contributing by almost 8% directly and 30% indirectly to Turkish economy. There are 40 construction firms in Turkey who receives the largest construction income in the world after 250 Chinese construction firms and leading 39 United States construction firms in the top performers list (INTES, 2017). However, very small attention has been given to the problems and challenges of the architecture and engineering firms that provide design documentation for the Turkish Construction Industry. Like other countries, Small-Medium Enterprises (SME) consists the majority of all enterprises in Turkey (Kapısız, 2013). Although SMEs are having this kind of majority in the sectors,

there is a gap in the literature about Turkish SME architecture and engineering firms' handicaps on BIM adoption as well as in BIM maturity.

Considering the cost savings provided by BIM implementation in the construction industry, it necessary for this study to draw the frame of BIM maturity fields, investigate the handicaps and set forth the factors causing deficits during the BIM adoption.

1.2 Aim and Objectives

The current study aims to explore the current SME design firm's BIM adoption environment, and to determine and evaluate the deficits of their BIM maturity. The objectives are listed as follows:

- To conduct an initial field research to describe the BIM adoption environment in Turkish SME architectural and engineering firms.
- To evaluate and discuss the BIM maturity areas that firms are weak according to the data derived from maturity assessment.
- To search the factors at the background that causes deficits in BIM maturity among Turkish SME architectural and engineering firms.
- To validate the findings.

1.3 Research Methodology

Research frame starts with an initial field study in order to detect the shortcomings of BIM implementation areas that Turkish design firms are suffering from. After

evaluating the results of the initial research findings, factors at the background of these deficits BIM implementation areas were analyzed. Later, a comparison was conducted between the practices in other countries and Turkey in order to understand the handicaps of the sector considering the key terms and aspects derived from literature. This process was followed by an evaluation and analysis section with same key BIM terms by defining two valid scenarios, which were observed during the initial field research. After analyzing and discussing the findings in terms of two scenarios, the findings were then compared with the survey results, later conducted with participant of assessment study. Then both of the results derived from the evaluation session and assessment study were compared. The overall research process of this study is depicted in Figure 1.

CHAPTER 2

2 BIM, BIM IMPLEMENTATION AND BIM MATURITY ASSESSMENT

In this section, a comprehensive literature review was conducted about BIM, BIM implementation and BIM maturity assessment.

2.1 Building Information Modeling – BIM

Building Information Modeling (BIM) is an information based system that includes concepts of communication, integration, interoperability, knowledge and certainty; making it something beyond a software application (Jernigan, 2007). Due to rich content and wide scope of BIM, there are a lot of definitions and terms produced such as object-oriented modeling, project modeling, virtual design and construction, virtual prototyping, integrated project databases and the last and widely accepted naming is building information modeling (Aranda-Mena, Crawford, Chevez, & Froese, 2009). Each definition represented according to its field of application. Although there are many definitions of BIM, the National Building Information Modeling Standards - United States (NBIMS-US) (2015) definition is accepted and used in this study due to its wide acceptance (Aranda-Mena et al., 2009; Azhar, Khalfan, & Maqsood, 2012; Barlish & Sullivan, 2012; Ding, Zhou, & Akinci, 2014; Hamdi, 2014; Joannides, Olbina, & Issa, 2012; John, Heap-Yih, & Christopher, 2015; Smits, van Buiten, & Hartmann, 2016; Staub-French et al., 2011; Suerman & Raja, 2009; Wong et al., 2009):

BIM is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.

AEC industry working practices has been characterized as inter-disciplinary and inter-organizational collaboration with limited and unlimited modes of innovation (Dossick, Neff, & Homayouni, 2009). A building project is developed, constructed and operated in this collaboration environment. Project delivery method and project participant's relationships effect the procedure and efficiency of projects (CURT, 2010). Although, BIM does not require a specific project delivery method to work with, in order to demonstrate its impact on project phases, traditional project delivery method may be compared with Integrated Project Delivery (IPD). This is due to fact that BIM process work best in a collaborative environment (CURT, 2010). The Figure 2 represents the differences between. While in traditional project delivery method, project participants' relations are fragmented and diverse, IPD provides an environment that project participants could be inside the project phases and in relation with each other starting from the early phases of project. As a result of this relationship, most of the design and design document related failures could be recognized and eliminated at early phases of the project, hence, decreasing the reworks and unanticipated costs in construction. That is the one of the most beneficial contribution of BIM to the AEC industry (McGraw-Hill, 2012). The impact of BIM to design and construction phase comparing with traditional delivery method in terms of cost of design changes and ability to impact cost and design changes are studied and illustrated in MacLeamy curve in Figure 3.

Table 2. *Continuing*

Forensic Analysis (Azhar, 2011)	It is possible to adapt the model to graphically demonstrate potential failures, leaks, evacuation plans and so forth.
Fabrication/Shop Drawings (Azhar, 2011)	It is possible to work with different working scale in a BIM model which enable production of fabrication/shop drawings
Faster and More Effective Process (Azhar, 2011; Migilinskas et al., 2013)	Information could more easily produced, stored, used and shared than traditional working practices.
Improved Design (Azhar, 2011; Migilinskas et al., 2013)	Due to accurate information, faster communication and data sharing, increased collaboration and reduced fragmentation enable improved and innovative solutions.
Increased Control (Azhar, 2011; Migilinskas et al., 2013)	Due to transmission of building data to digital environment, increased communication, increased collaboration, project participants control is increased across all project phases.
Increased Communication (Azhar, 2011; Masood et al., 2014; Migilinskas et al., 2013)	Due to faster, consistent and accurate data sharing, communication between project participants are improved and increased. Better visualization options provided by BIM is also decreased the misunderstandings of project participants.
Life-Cycle Data (Azhar, 2011; Meadati et al., 2011)	A BIM model have the opportunity to store whole project life-cycle data in virtual environment including requirements, specifications, design, construction and operation information.

2.1.2 Barriers to Adoption of BIM

Considering the current literature, it is possible to examine the barriers (shown in Table 3) to adoption of BIM under three main areas. (1) legal issues, (2) practical / software related deficiencies, (3) cost. In most of the literature, main focus in terms of barriers of BIM implementation is collected on legal issues. This is due to fact that BIM brings new approaches to the working fields resulting with new business relations to be formed and described.

Table 3. List of the handicaps of BIM

Barriers to Adoption	**References**
Legal issues	(Arensman & Ozbek, 2012; Olatunji, 2011)
Practical and Software related Deficiencies	(McGraw-Hill, 2012; Migilinskas et al., 2013; Olatunji, 2011)
Cost of BIM implementation	(McGraw-Hill, 2012; Migilinskas et al., 2013; Olatunji., 2011a; Wong et al., 2009)

Legal Issues

Legal issues related with BIM implementation include model ownership, right to rely, shifting of risk, standard of care and BIM compensation (Arensman & Ozbek, 2012; Olatunji, 2011). An explanation of these legal issues are listed in Table 4.

Table 4. Legal Barriers of BIM

Legal Barriers of BIM	**Explanation**
Model Ownership	Throughout the project execution among project participants, model is possible to be generated by different project participants depending on the project delivery method, contractual agreement and protocols. Considering these project participants' relationships, it is a question for the project participants to be owner of the model. AIA and CIC developed different point of view for the model ownership. AIA proposes agreement of project participants about model ownership and intellectual property rights at the phase of signing contract, however; CIC allocate intellectual property right to model author. There is no common accepted standard on this issue among the AEC industry. This uncertainty causes a barrier for the firms to adopt BIM practices.

Table 4. *Continuing*

Right to Rely	Accuracy of the digital data and model information during the use, copy and transmission is needed to be guaranteed. Otherwise, conflict arises in case of failure due to the inaccuracy of data and information derived from model. Like in the case of model ownership, AIA and CIC developed different perspectives for this issue. Both of the entities allocate different liabilities and duty for the project participants. While AIA allocate the responsibility to provide accurate digital data to the transmitting party (AIA, 2013), CIC does not give any liability to project team member or model author on providing accurate data transmitted to other project participants (CIC, 2013). Thus, this uncertainty stimulate doubt of the firms to adopt BIM.
Shifting of Risk	BIM provide collaborative working process that project participants work so closely with each other. This situation causes changes on risk allocation. Traditional working practices, like in Turkish example, are based on definite responsibility and duty of the parties. However, collaborative working environment provided to the project participants with BIM enables early participation of project participants in the design phase. In this case contractor may be concerned with design liability. This issue is also handled in different ways in both AIA and CIC. Although the AEC industry has two different perspectives like AIA and CIC, there are countries that has not yet provided guidance to BIM practices like in Turkey. Thus, this situation has potential to cause conflicts among project participants, therefore; firms could see this issue as barrier in front of BIM adoption.
Standard of Care	Due to its promises for increased innovation and collaboration, expectations from BIM has also naturally increased. It means that clients have higher expectations considering the skill and care that is practiced by architect.
BIM Compensation	Considering the cost of BIM implementation, increased responsibility of architect and increased standard of care of the services, especially architect and other project participants demand higher cost for their services. However, from the client's perspective, due to decrease on construction cost, project budget is smaller than in traditional working practices. In this case while, design team in a project such as architect and engineer demand higher cost for their services, client states that the increased cost in the traditional service is due to the low quality of the services provided by design team. Therefore, client is not volunteer to pay extra compensation for the services provided by design team.

Practical and Software Related Deficiencies

As a result of at least two decades of BIM experience, various case studies indicate that although it provides obvious opportunities to the project participants, BIM tools still demonstrate not only practical but also software related deficiencies (Migilinskas et al., 2013; Wong et al., 2009). Most of these handicaps have to be confronted during the execution of BIM. Due to existence of practical and software related deficiencies, BIM adoption is still a challenging issue that limits the effective use of BIM in the industry. The practical and software related deficiencies are presented in the following points:

- Although there are existing practical BIM tools and software, during the adoption process until the organization get used to the new concept, the firms at initial phases of adoption still needed to use traditional tools. These tools cause problems due to non-existence of interoperability options with BIM software. Therefore, additional effort is needed to regenerate the digital data in BIM environment. This situation also limit the data transfer among project participants. Thus, ideal collaboration environment could not to be established to work efficiently with BIM (Migilinskas et al., 2013; Wong et al., 2009).

- Lack of experience on execution of BIM causes a decrease on the efficiency of the process (Migilinskas et al., 2013).

- It has been observed that lack of support from senior leadership of companies creates a decrease on the motivation of BIM adoption among staff (Migilinskas et al., 2013).

- Lack of strict BIM implementation standards, rules for certain project participants and contractual obligations also become a handicap for the project participants to adopt BIM (Migilinskas et al., 2013).

- Resistance to change is also reported as a handicap for BIM adoption (Migilinskas et al., 2013; Wong et al., 2009). In traditional practice, the designer creates the design whereas the draftsman generates the drawing from the designers study. However, integrated and collaborated working environment that BIM provides to project participants remove this diversity and make it necessary to work together which takes time for a change in their working habits. This resistance to change observed inside the organizations has also been seen in interoperability and collaboration practices among disciplines. BIM enables early inclusion of project participants in design, which is not a familiar scene in the traditional practice. Considering the design-bid-build delivery method, contractor and architect has no direct relation with each other until bidding phase. However, in BIM practice, it is necessary to work together in order to get maximum benefit (CURT, 2010). Thus, getting rid of traditional working habits is another challenge for BIM adoption.

- It is studied that (Olatunji., 2011a), the choice of organizational structure such as network, divisional, functional and matrix impact BIM adoption. Matrix organizations in which business relationships are horizontal are more successful in BIM adoption due to compliance of organizational structure with integrated and collaborated working environment of BIM. However, functional organizations, in which the business relationships are vertical, are less successful in BIM adoption. It is more familiar to confront with resistance to change in functional organizations than in matrix organizations.

Cost of BIM Implementations

One of the prominent obstacles of BIM is the cost of BIM implementation (McGraw-Hill, 2012; Migilinskas et al., 2013; Olatunji., 2011a; Wong et al., 2009). Remarkable investment is needed to get benefit from various opportunities of BIM. Olatunji (2011) defined the parameters of cost of BIM implementation in SME design firms. Furthermore, the cost percentages of those parameters are resulted in the same study as shown in Figure 4.

Based on the parameters of cost of BIM implementation described by Olatunji (2011), a search for cost calculation of BIM implementation in Turkey was also investigated in this study. Available software costs in Turkey were derived from authorized software distributers. Balanced working hardware requirements for software were derived from software websites. The cost of hardware that meet the balanced performance working requirements of software were derived from hardware distributers. The same cost investigation method was also followed for other cost items. However, it has been observed that there was either variety or lack of some cost items such as training, technical support, services etc. for implementation in Turkey. Therefore, for those cost items, the percentages based on software licensing calculated by Olatunji (2011) were accepted as cost items. Cost items and results of this study is presented in Table 5. As a result, BIM implementation cost for one staff member is within a range of $ 10200 (USD) and $ 14800 (USD) in Turkey.

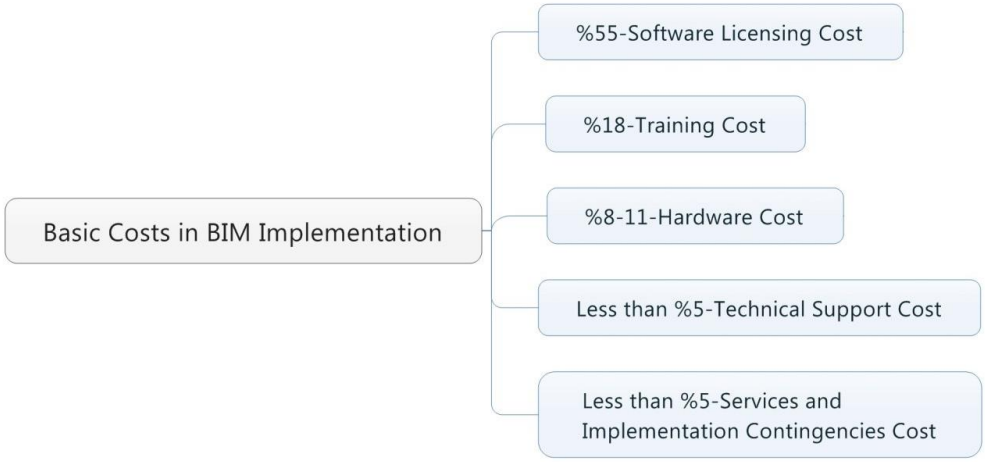


Figure 4. Basic costs of BIM implementation in SME organizations stated by (Olatunji., 2011a).

Table 5. Cost of BIM implementation for one staff in Turkey. The percentages of cost items were adopted from:(Olatunji., 2011a). Licensing cost was collected from authorized software distributers in Turkey in 2017.

Cost Item	**Cost**
Licensing	$5000 - $8200
Training	$1700 - $2700
Hardware (Balanced Performance)	$2000 - $3000
Technical Support and Others	$500 - $800
Total	$10200-$14800

2.2 BIM Implementation

BIM implementation includes a couple of terms such as practice, process, project participants's relationships and digital data. All of these items come together and gain meaning in BIM execution plan. Therefore, BIM implementation subject in this study is presented under the topic of BIM execution plan. Due to its rich content and offering varying relationships of project participants to BIM, preparation and utilization of BIM execution plan is offered by best practice guides

(AEC UK Initiative, 2012; CICRP, 2010; CURT, 2010). Furthermore, preparation of BIM execution plan is directly advised in AIA Document E203-2013 and indirectly obligated in CIC BIM protocol, which is further explained in Chapter 4. The objectives of preparation of a BIM execution plan are (CICRP, 2010):

- Description of, and agreement on strategic goals for implementing BIM on project among project participants
- Description of role and responsibilities of project participants
- Outlining additional requirements for effectively use of BIM among project participants such as training of staff, hardware and software requirements *etc*.
- Providing a timeline record for the future project participants that are participated the project in later process
- Providing a measurement environment for the project participants to evaluate their success on achieving their responsibilities as it is described in the BIM execution plan.

There are four steps of successfully implementing a BIM execution plan described by best practice guides (CICRP, 2010; CURT, 2010):

1. Identifying BIM goal and uses
2. Designing BIM project execution process
3. Developing information exchanges
4. Defining supporting infrastructure for BIM implementation

The basic terms and information that a BIM execution plan includes, which are derived from literature, are presented in Table 6.

Table 6. Basic terms and information taken place in a BIM execution plan

Terms & Information	Explanation
BIM Project Execution Plan Overview Information (CICRP, 2010)	Demonstrating aim and scope of the preparation of BIM execution plan
Project Information (CICRP, 2010)	Critical project information should be mentioned such as project numbers, project location, project description, critical schedule dates, *etc*.
Key Project Contacts (CICRP, 2010)	Information related with key project personnel should be included.
Project Goals/BIM Objectives (CICRP, 2010; CURT, 2010)	Strategic value and specific uses of BIM project execution planning should be described.
Organizational Roles and Staffing (AEC UK Initiative, 2012; CICRP, 2010; CURT, 2010)	Assigning the roles of project participants, identifying project coordinator who will prepare and manage the BIM execution plan in procedure in various stages of project development, and defining the necessary staff for successfully implement the BIM execution plan.
BIM Process Design (AEC UK Initiative (2012); CICRP, 2010)	Illustration of execution process through the use of process map includes the detail schema of roles, relations and information exchanges of project participants
BIM Information Exchanges (AEC UK Initiative, 2012; CICRP, 2010; The BIM Comittee, 2009)	The model elements and level of details in each use should be clearly described.
BIM and Facility Data Requirements (CICRP, 2010; CURT, 2010)	The owner requirements for BIM must be clearly indicated and understood
Collaboration Procedure (AEC UK Initiative, 2012; CICRP, 2010; CURT, 2010)	The project team should develop their electronic data exchange and collaboration activities including model management procedures, typical meeting schedules and agendas.

Table 6. *Continuing*

Model Quality Control Procedure (CICRP, 2010)	A procedure for monitoring the project participants so that they meet their defined requirements for roles and responsibilities depicted in BIM execution plan
Technology Infrastructure Needs (AEC UK Initiative, 2012; CICRP, 2010)	The required hardware, software and network infrastructure to execute the plan should be defined.
Model Structure (AEC UK Initiative, 2012; CICRP, 2010)	The project team needs to discuss and indicate items such as model and file naming structure, coordinate system and modeling standards.
Project Deliverables (CICRP, 2010)	The project team should record the deliverables required by the owner.
Interoperability (AEC UK Initiative, 2012)	Consideration of different software and file format options during digital data transfer is crucial in a collaborative working environment among project participants.
Data Segregation (AEC UK Initiative, 2012)	Data segregation includes multi-user access, operational efficiency on large projects and inter-disciplinary collaboration.
Modeling Methodology (AEC UK Initiative, 2012)	Model development methodology means development of projects in early stages that enables rapid model development and creation of large projects with low hardware requirements.
Delivery Strategy/Contracts (CICRP, 2010)	Delivery strategy should be identified. Depending on the delivery method such as design-bid-build, or design-build, contractual language and implementation procedure are set.

2.3 BIM Maturity Assessment

As the BIM adoption gaining popularity, question for content, information and areas that BIM process covers within an organization aroused (McCuen, 2008). First BIM assessment oriented tool was developed by National Building Information Modeling Standards (NBIMS) and released in 2007 called as Capability Maturity Model (CMM) (McCuen, 2008). NBIMS aims CMM to be used as a tool for the BIM users so that they can evaluate and develop their business practices. The CMM in tabular form is a matrix with having 11 areas of interest on x axis and 10 maturity levels on y axis which is presented in Figure 5. Then tabular form of CMM was developed to Interactive Capability Maturity Model (I-CMM) by NBIMS containing the same information with CMM but this time users can enter the information on a graphical user interface (McCuen, 2008). The I-CMM was presented in a multi-tab Microsoft Excel workbook aiming to make the information easier to understand.

Maturity Level	A Data Richness	B Life-cycle Views	C Roles Or Disciplines	G Change Management	D Business process	F Timeliness/ Response	E Delivery Method	H Graphical Information	I Spatial Capability	J Information Accuracy	K Interoperability/ IFC Support
1	Basic Core Data	No Complete Project Phase	No Single Role Fully Supported	No CM Capability	Separate Processes Not Integrated	Most Response Info manually re-collected - Slow	Single Point Access No IA	Primarily Text - No Technical Graphics	Not Spatially Located	No Ground Truth	No Interoperability
2	Expanded Data Set	Planning & Design	Only One Role Supported	Aware of CM	Few Bus Processes Collect Info	Most Response Info manually re-collected	Single Point Access w/ Limited IA	2D Non-Intelligent As Designed	Basic Spatial Location	Initial Ground Truth	Forced Interoperability
3	Enhanced Data Set	Add Construction/ Supply	Two Roles Partially Supported	Aware of CM and Root Cause Analysis	Some Bus Process Collect Info	Data Calls Not In BIM But Most Other Data Is	Network Access w/ Basic IA	NCS 2D Non-Intelligent As Designed	Spatially Located	Limited Ground Truth - Int Spaces	Limited Interoperability
4	Data Plus Some Information	Includes Construction/ Supply	Two Roles Fully Supported	Aware CM, RCA and Feedback	Most Bus Processes Collect Info	Limited Response Info Available In BIM	Network Access w/ Full IA	NCS 2D Intelligent As Designed	Located w/ Limited Info Sharing	Full Ground Truth - Int Spaces	Limited Info Transfers Between COTS
5	Data Plus Expanded Information	Includes Constr/Supply & Fabrication	Partial Plan, Design&Constr Supported	Implementing CM	All Business Process(BP) Collect Info	Most Response Info Available In BIM	Limited Web Enabled Services	NCS 2D Intelligent As-Builts	Spatially located w/Metadata	Limited Ground Truth - Int & Ext	Most Info Transfers Between COTS
6	Data w/Limited Authoritative Information	Add Limited Operations & Warranty	Plan, Design & Construction Supported	CM Capability	Few BP Collect & Maintain Info	All Response Info Available In BIM	Full Web Enabled Services	NCS 2D Intelligent And Current	Spatially located w/Full Info Share	Full Ground Truth - Int And Ext	Full Info Transfers Between COTS
7	Data w/ Mostly Authoritative Information	Includes Operations & Warranty	Partial Ops & Sustainment Supported	Implemented	Some BP Collect & Maintain Info	All Response Info From BIM & Timely	Full Web Enabled Services w/IA	3D - Intelligent Graphics	Part of a limited GIS	Limited Comp Areas & Ground Truth	Limited Info Uses IFC's For Interoperability
8	Completely Authoritative Information	Add Financial	Operations & Sustainment Supported	Implementing CM and Root Cause Analysis	All BP Collect & Maintain Info	Limited Real Time Access From BIM	Web Enabled Services - Secure	3D - Current And Intelligent	Part of a more complete GIS	Full Computed Areas & Ground Truth	Expanded Info Uses IFC's For Interoperability
9	Limited Knowledge Management	Full Facility Life-cycle Collection	All Facility Life-Cycle Roles Supported	CM and RCA capability implemented	Some BP Collect&Maint In Real Time	Full Real Time Access From BIM	Netcentric SOA Based CAC Access	4D - Add Time	Integrated into a complete GIS	Comp GT w/Limited Metrics	Most Info Uses IFC's For Interoperability
10	Full Knowledge Management	Supports External Efforts	Internal and External Roles Supported	Implementing CM & RCA and feedback	All BP Collect&Maint In Real Time	Real Time Access w/ Live Feeds	Netcentric SOA Role Based CAC	nD - Time & Cost	Integrated into GIS w/ Full Info Flow	Computed Ground Truth w/Full Metrics	All Info Uses IFC's For Interoperability

Figure 5. Tabular Capability Maturity Model (CMM) released by NBIMS (McCuen, 2008).

After the release of CMM by NBIMS, there has been various BIM maturity assessment tools released for the utilization of practitioners. Although various studies have been conducted on BIM maturity assessment since the release of NBIMS-CMM, Giel et al. (2013), Giel & McCuen (2014) Giel & Issa (2016) are the only studies that categorize, compare and synthesize the available BIM maturity assessment tools (Giel & Issa, 2013, 2016; Giel & McCuen, 2014). Giel & McCuen (2014) categorized BIM maturity assessment tools into three categories as shown in Figure 6. These are people driven, process driven and product driven. Giel & Issa (2016) compared the available assessment tools as shown in Table 8. The comparison parameters utilized in Giel *et al*. (2016) study which is depicted in Table 8 are explained in Table 7. Considering these parameters stated in Table 8 and categorization illustrated in Figure 6, in order to stay within the objectives of this study and not to expand the topic unnecessarily, only the assessment tools in organization evaluation category and the tools that intended user group includes architecture and engineering are explained in this section. Thus, in terms of these parameters and categorization, BIM Maturity Matrix, BIM Quickscan and BIM proficiency matrix are examined and explained shortly in the following phases of this section.

Table 7. BIM maturity assessment tools comparison parameters utilized by Giel & Issa (2016). Adopted from: (Giel & Issa, 2016)

Intended User Group	A: Architecture, E: Engineering C: Construction O: Operation
Rating Context	Represent the evaluation area, criteria or entity. For example: - Evaluation of information management on building projects, - Evaluation of organizations, projects, teams or individuals - Evaluation of designers and contractors ability to provide BIM services - Evaluation of BIM performance level of organizations providing BIM services - Evaluation of project BIM performance and project BIM maturity - Evaluation of Owner's maturity of BIM planning strategies

- Chapter 1: Organization and management
- Chapter 2: Mentality and culture
- Chapter 3: Information structure and information flow
- Chapter 4: Tools and applications.

Each chapter includes a number of KPIs in the form of a multiple-choice questionnaire. The total number of question is limited to 50 in order to provide not only an in-depth scan but also the services in a reasonable speed. Each KPI has a certain weighting factor. The sum of all the partial scores regarding the weighting factor gives the overall BIM performance score of the organization. Not like the BIM Maturity Matrix, if two firms demonstrate same BIM performance score, it is possible to compare these two firms. In other words, BIM QuickScan provide consistent benchmarking score for the organization, enabling comparison of BIM performance score. The tool also provides a radar diagram based on the result of the organization depicted in Figure 12.

Table 9. Guiding principles of BIM performance benchmarking. Adopted from: (Sebastian & Berlo, 2010; Succar, 2010)

Accurate	Clear, non-falsifiable and allow accurate, repeatable assessment.
Applicable	Can be utilized by all stakeholders across project life-cycle phases.
Attainable	Benchmarks can be achieved through progressive accumulation of defined actions.
Consistent	When conducted by different assessors, measurements yield the same results.
Cumulative	Benchmarks are set as logical progressions; deliverables from one benchmark act as pre-requisites for another.

Table 9. *Continuing*

Flexible	Assessments can be performed across markets, organization scales and their subdivisions.
Informative	Measurements provide 'feedback for improvement' and 'guidance for next steps'.
Neutral	Measurements do not prejudice proprietary, non-proprietary, closed, open, free or commercial solutions or schemata.
Specific	Metrics are well defined and serve industry-specific assessment purposes.
Usable	Metrics are intuitive and can be easily employed to assess BIM performance.

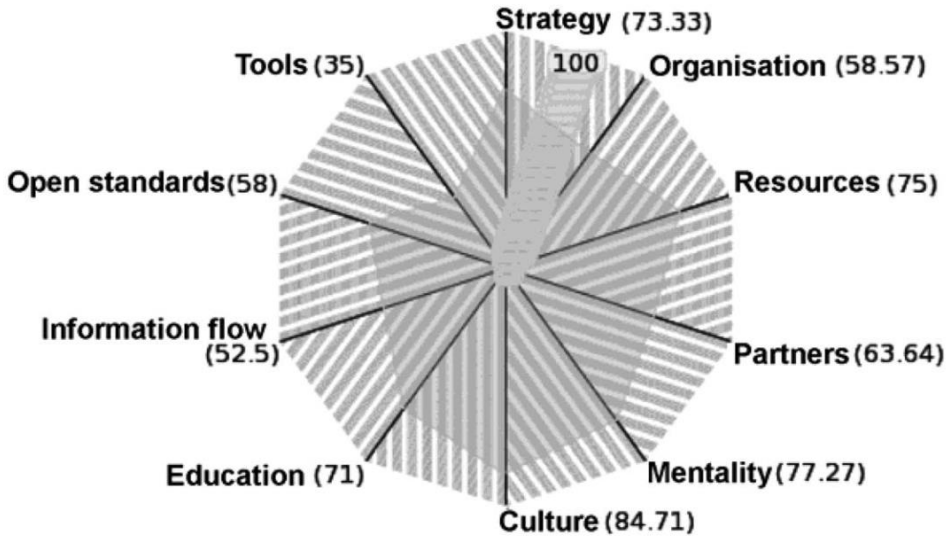


Figure 12. Radar diagram provided by BIM Quickscan.

Although both of them established upon same guiding principles of BIM performance benchmarking, the main differences of BIM Quickscan with BIM Maturity Matrix are:

- While BIM Maturity Matrix gives overall BIM maturity performance of an organization considering the BIM services and products, BIM Quickscan

gives organization specific BIM performance results which are open to comparison and more consistent than BIM Maturity Matrix.

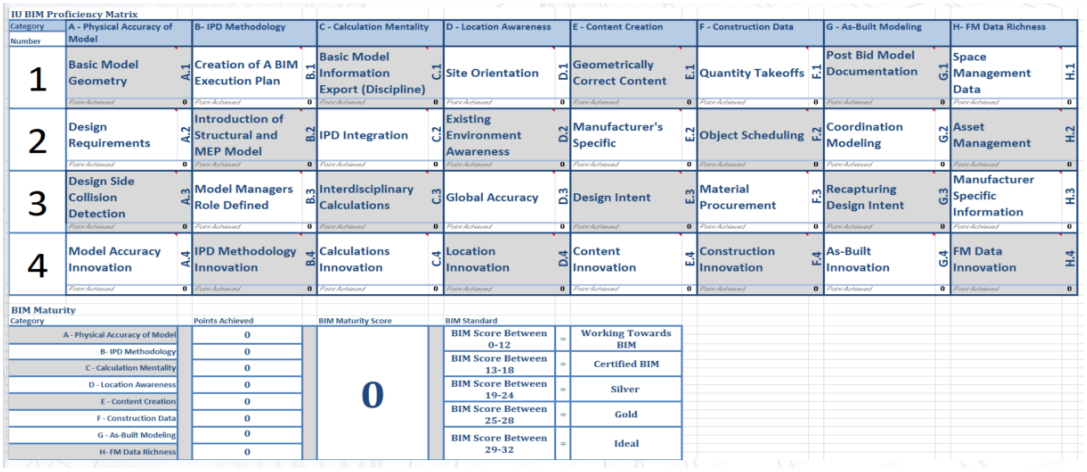
- Although both of the assessment tools established upon same KPIs, BIM Maturity Matrix does not utilize weighting factor on BIM score whereas, BIM Quickscan not only utilizes weighting factor but also gives further development strategies for the organizations regarding the KPIs.

- BIM Maturity Matrix presented in tabular form in which all of the maturity levels and explanations are clearly visible and the tool enable multiple-evaluation style. However, BIM Quickscan necessitates online questionnaire in which the KPIs are hidden at the questions.

- While BIM Maturity Matrix enables organizational assessment, BIM Quickscan enable both model and organization assessment. Therefore, survey question ask information and knowledge related with both organization and project model.

2.3.3 BIM Proficiency Matrix

BIM Proficiency matrix was developed by Indiana University in order to let the owner to measure the BIM experience level of designers and contractors. The tool is presented in MS excel format. Eight areas of interests against four maturity levels are provided for evaluation as illustrated in Figure 13. Each user enters the related project data and information to the Microsoft Excel file and then a consultant grades the information and data. Each area of interest has equal value and maximum score is 32 points. BIM proficiency matrix usage is obligatory by Indiana University BIM Standards for the projects developed for Indiana University (IU, 2009).



IU BIM Proficiency Matrix

Category Number	A - Physical Accuracy of Model	B- IPD Methodology	C - Calculation Mentality	D - Location Awareness	E - Content Creation	F - Construction Data	G - As-Built Modeling	H- FM Data Richness
1	Basic Model Geometry A.1	Creation of A BIM Execution Plan B.1	Basic Model Information Export (Discipline) C.1	Site Orientation D.1	Geometrically Correct Content E.1	Quantity Takeoffs F.1	Post Bid Model Documentation G.1	Space Management Data H.1
	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0
2	Design Requirements A.2	Introduction of Structural and MEP Model B.2	IPD Integration C.2	Existing Environment Awareness D.2	Manufacturer's Specific E.2	Object Scheduling F.2	Coordination Modeling G.2	Asset Management H.2
	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0
3	Design Side Collision Detection A.3	Model Managers Role Defined B.3	Interdisciplinary Calculations C.3	Global Accuracy D.3	Design Intent E.3	Material Procurement F.3	Recapturing Design Intent G.3	Manufacturer Specific Information H.3
	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0
4	Model Accuracy Innovation A.4	IPD Methodology Innovation B.4	Calculations Innovation C.4	Location Innovation D.4	Content Innovation E.4	Construction Innovation F.4	As-Built Innovation G.4	FM Data Innovation H.4
	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0	Point Achieved 0

BIM Maturity

Category	Points Achieved
A - Physical Accuracy of Model	0
B- IPD Methodology	0
C - Calculation Mentality	0
D - Location Awareness	0
E - Content Creation	0
F - Construction Data	0
G - As-Built Modeling	0
H- FM Data Richness	0

BIM Maturity Score: 0

BIM Standard		
BIM Score Between 0-12	=	Working Towards BIM
BIM Score Between 13-18	=	Certified BIM
BIM Score Between 19-24	=	Silver
BIM Score Between 25-28	=	Gold
BIM Score Between 29-32	=	Ideal

Figure 13. BIM Proficiency Matrix. Original file downloaded from: http://www.iu.edu/~vpcpf/consultant-contractor/standards/bim-standards.shtml

Although BIM Proficiency Matrix usage is obligatory by Indiana University and Indiana University provides its own BIM Standards, BIM Proficiency Matrix is not widely accepted as NBIMS-CMM. However, it is the first application released including the owner perspective and evaluation parameters specific to owner evaluation.

CHAPTER 3

3 AN INVESTIGATION OF BIM MATURITY ASSESSMENT AMONG TURKISH SMALL-MEDIUM SIZE ENTERPRISES ARCHITECTURE AND ENGINEERING DESIGN FIRMS

In this section, a BIM maturity investigation study is structured according to the conditions in Turkey. Considering the Author's initial experiences on BIM adoption survey in Turkey, features of available BIM maturity assessment tools, and objectives of this thesis, a search for appropriate BIM maturity assessment tool to utilize in Turkey is argued. Then after the selection of an appropriate assessment tool, the evaluation procedure is explained. Later, BIM maturity assessment results and BIM implementation notes are presented under sub-topic of each selected firm. At the end of this section, overall conditions of the firms are discussed considering their common BIM maturity performances. Furthermore, in order to validate the findings of this chapter, the results were compared with the development reports prepared by Ministry of Development of Turkey. Following chapters of this thesis are established upon the results and conclusions collected from field research studied in this chapter.

3.1 Current Conditions in Turkish AEC Industries

Construction sector is one of the driving forces of Turkish economy having 8% direct and 30% indirect ratio in overall economic income (INTES, 2017). Furthermore, there are 40 Turkish construction firms receiving world's second largest construction income following the China (65 firms) and leading United

States (39 firms) in the annual list of international construction statistics (INTES, 2017).

Starting from the early 20th century, especially in Middle East and North Africa region, economic prosperity coming from petroleum products has created the collection of funds in these countries (Dunn, 2004). The countries have started to spend these reservoirs by investing on development of the countries. However, these countries did not have technological and intellectual capability to design, construct and operate these investments (Dunn, 2004). Therefore, developed countries took over these responsibilities. On the other hand, gained experiences in these projects emerged cultural differences and unsatisfactory project completions. This situation have created job opportunities for Turkish construction and technical consultancy firms (TCKB, 2013). Having cultural and historical background and easy logistical support opportunities have increased the economic relations of Turkey with Middle East and North African countries (TCKB, 2013). Therefore, this situation in Middle East and North Africa region increase the capability and competency of construction sector firms in Turkey. Furthermore, due to its being a developing country, governmental infrastructure investments promises great job opportunities for the AEC industry practitioners in Turkey (INTES, 2017).

Success of Turkish construction firms provide not only a practical experience but also a self-confidence on taking further job opportunities (INTES, 2017). However, the success of Turkish construction sector does not reflect the same success in technical consultancy sector providing design and drafting services to construction industry. There are various problems and handicaps that technical consultancy firms suffer from (TCKB, 2013).

Like in the public procurements, most of the private procurements are delivered with traditional approaches in Turkey (TCKB, 2013). Traditional project delivery

approach forces the firms to decrease the costs. Contractors in this case decreases not only the design and documentation but also supply chain costs. This situation causes ignoring of quality of the product and services delivered (TCKB, 2013). Combining these handicaps with low level worth and compensation of design and drafting services in Turkey do not enable technical consultancy firms to invest on technological and innovative working methods (TCKB, 2013). Although having 40 construction firms in the world largest construction firm lists, the technical consultancy sector that providing design and drafting services to construction industry does not have the same success as occurred in construction industry. This situation differs Turkish AEC industry from other countries. Therefore, this study focuses on BIM maturity assessment of technical consultancy firms giving services in Turkey.

3.2 Selection of BIM Maturity Assessment Tool

There are several BIM maturity assessment tools released so far, starting with NBIMS Capability Maturity Model (CMM) in 2007 (NBIMS, 2007). Each of the assessment tools are specific and based on certain metrics (Abdirad, 2016; Giel & Issa, 2013). Most of the BIM maturity assessment tools focus on the quantitative metrics that evaluate projects, people and organizations (Abdirad, 2016; Giel & Issa, 2013; Kam et al., 2013; Sebastian & Berlo, 2010). However, in this study, the research scope is limited within organizational boundary. This is for looking at the topic from a wider perspective as stated in the objectives, for describing the overall BIM adoption environment in Turkish AEC practices.

Before the BIM maturity assessment research, the author of this thesis attempted to conduct a survey to search for BIM adoption environment among architecture and engineering firms in Turkey. Due to not reaching enough number of participation, the survey was not published and utilized in this study. However, the experiences confronted during that research address the handicaps and challenges of making

research among architecture and engineering firms in Turkey. Therefore, the experiences of that attempt was found noteworthy to mention in this section. It has been observed during the survey that, the terms related with BIM were unfamiliar and unknown to survey participants, which was causing misunderstanding and confusion among them. Furthermore, the situation led survey participants to early cancel of survey without completing the questions. Moreover, the survey participants were not volunteering to give away project information for privacy concerns. It has also been observed that, although some of the firms were implementing BIM practices, they were not familiar with the specific BIM terms for naming their practices. Therefore, considering the above situation confronted during the survey, the assessment tools needed to be easy to understand, easy to implement and should include explanatory items in order to prevent misunderstandings and confusions.

After mentioning the initial experiences of research, the below listed items were considered during the selection of appropriate BIM maturity assessment tool for application in this study:

- Lusthaus *et all* (2002) indicate that organizational performance, organization's external environment, organizational motivation and organization capacity are the four metrics of qualitative organizational assessment (Lusthaus, Adrien, & Montalván, 2002). Therefore, the assessment tool needed to evaluate organizational BIM performance. Thus regarding categorization illustrated in Figure 6, organization assessment tools are appropriate for this study.

- Considering the earlier experiences on survey about BIM adoption which is indicated in this section, in order not to lead to misunderstandings, the assessment tool needed to be easy to apply and needed to include

explanations for each maturity level. Therefore, it was decided that assessment tool in tabular form was easier to apply than other formats such as excel data input provided by BIM Proficiency Matrix and online questionnaire provided by BIM Quickscan.

- Regarding the earlier experiences on survey about BIM adoption, as indicated in this section, the firms prefer not to share private information such as project model, cost, budget, and investment. Although there are contractual liabilities of designers to owners on reserving and not sharing project information to other parties and entities (TMMOB, 2006), there are also safety concerns of design firms, such as abuse of project information. Due to this fact, application of assessment tool that require model data is difficult to apply.

- The objectives of this study is limited to organizational assessment which is desired to lead to detection of the common barriers and common benefits of BIM adoption in Turkey without considering the size, market and location of the firm in practice. Furthermore, there is no intention on comparison of BIM performance of two or more firms.

- Technical consultancy firms suffer from low profits of the services, inadequate contractual relations and outdated legal obligations (TMMMB, 2015). This situation causes a variety of quality of the services and products (TCKB, 2013). Therefore, rather than looking for observation of maintained quality of services and products in each projects, it is reasonable to observe and derive data from products and services in which adequate working conditions are provided such as, adequate profit, adequate requirements and interdisciplinary relationships, *etc.* In these circumstances, it is not reasonable to select a BIM maturity assessment tool benchmarking project

model parameters such as BIM Quickscan. Therefore, it is acceptable to select an assessment tool evaluating only organizations regarding the experiences of organization's best practices. This way, the research outcomes will depict the capability of the firms and that is an acceptable way to derive data from firms in Turkey for this study.

Based on the stated items in this section, BIM Maturity Matrix is selected for application due to the following reasons:

- BIM Maturity Matrix is presented in tabular form and clearly explains each maturity level by indicating actions and requirements that is to be observed in related level. Thus, during the assessment, it is possible to explain the maturity levels to the participant and it is possible to negotiate on the maturity level of the firm with participant.

- BIM Maturity Matrix includes rich domain of BIM and BIM – based services and deliverables. Therefore, there is no need to examine model data. In other words, it is possible to complete a BIM maturity assessment in one or two sessions. This situation makes research easy to conduct and does not take any negative attention of the firms in terms of model and digital data sharing.

- Conducting the research with tabular form of BIM Maturity Matrix with noting the firms applications and practices enabled collection of much more BIM implementation experience data than online survey did. During the assessment, for each maturity area, first, an explanation was provided to the participant and then they were asked about their own experiences on related BIM maturity area. Later, the participants talked their own experiences. As a result, by using this data collection method in BIM maturity assessment, not only the firms provided information to detect BIM maturity level, but also it was possible to learn about the BIM practices of the firm on that BIM maturity area. Indeed, in this way, BIM Maturity Matrix behaved as a platform to talk about the BIM practices of the firms.

3.2.1 BIM Maturity Assessment Procedure

Succar (2010) not only released BIM Maturity Matrix but also provided an application procedure. In this section, BIM Maturity Matrix assessment procedure is reviewed and according to the workflow, the assessment procedure is applied.

Figure 14. BIM Maturity Matrix application workflow (Succar, 2010).

As stated in Figure 14, the assessment procedure includes identification of organizational scale, identification of competency granularity levels, detection of capability stages, and then detection of maturity levels. After conclusion of evaluation, it is possible to derive both evaluation score and diagram. In the following parts of this section, BIM maturity assessment workflow is explained in detail.

3.2.2 Identification of Organizational Scale

Variety of measurement scale make it necessary to define ranges of magnitudes of organizations. In order to meet factors arising from variety of organizational scale, Succar developed organizational hierarchy illustrated in Figure 15 (Succar, 2010). Hierarchic categorization enables variety options of evaluation. Thus, starting from industry scale, it is possible to evaluate organizations, organizational units, organizational teams or organizational members. Content and limit of organizational scale characteristics are illustrated in Figure 16. Before starting the assessment, the first step is the identification of assessment scale.

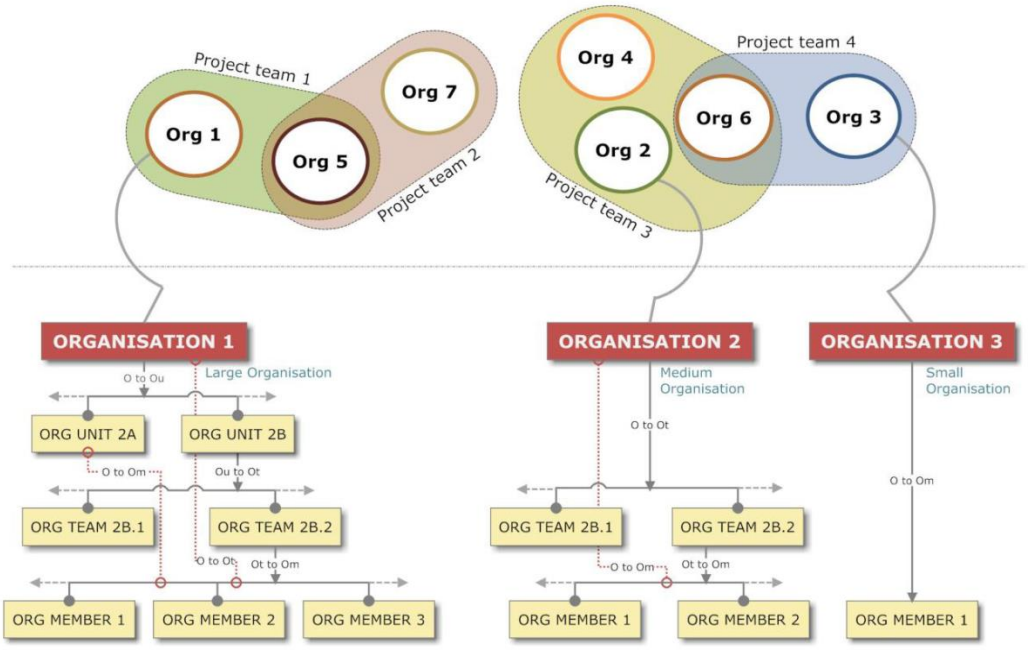
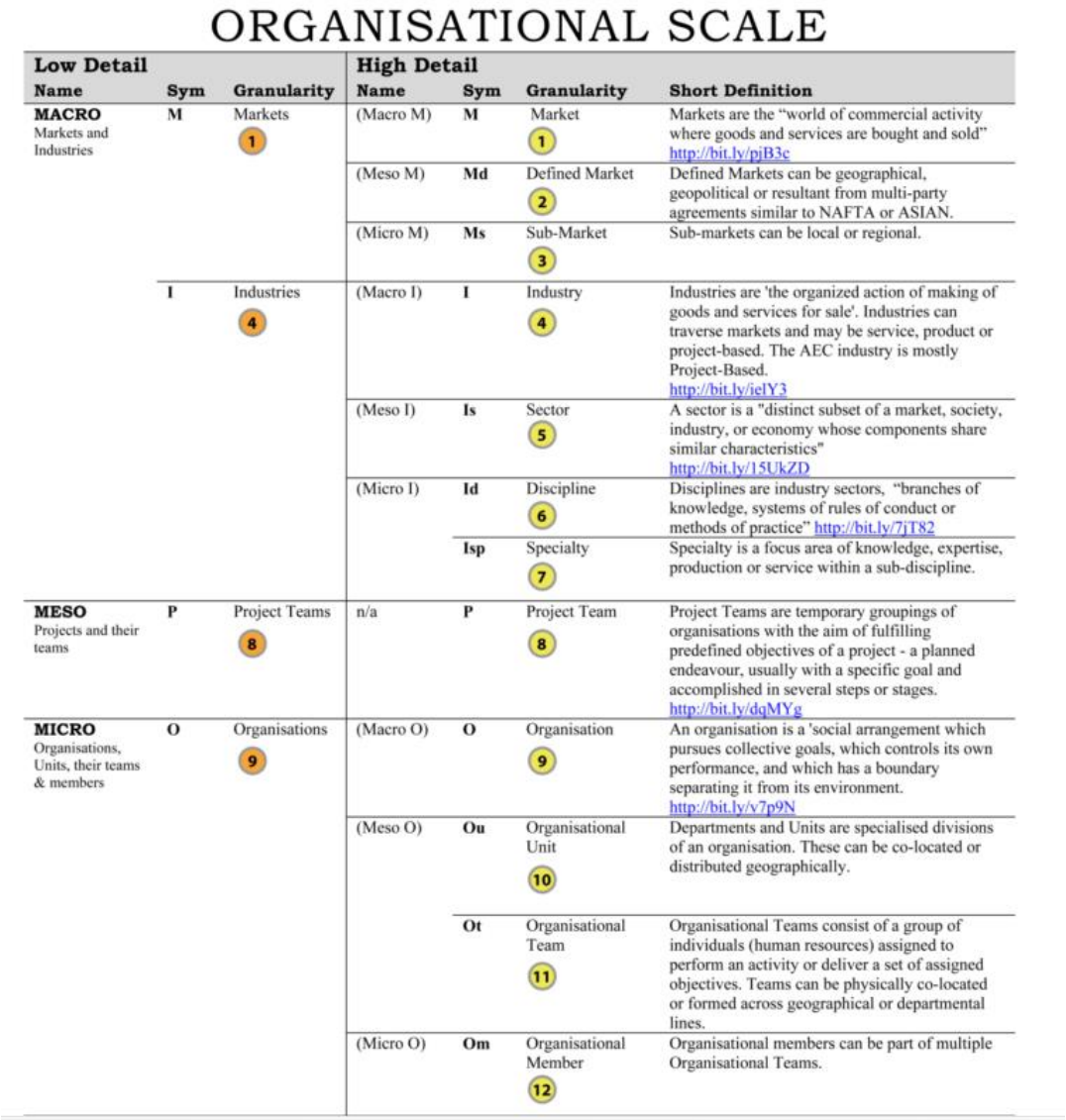


Figure 15. Organizational hierarchy (Succar, 2010).



ORGANISATIONAL SCALE

Low Detail			High Detail			
Name	**Sym**	**Granularity**	**Name**	**Sym**	**Granularity**	**Short Definition**
MACRO Markets and Industries	**M**	Markets 1	(Macro M)	**M**	Market 1	Markets are the "world of commercial activity where goods and services are bought and sold" http://bit.ly/pjB3c
			(Meso M)	**Md**	Defined Market 2	Defined Markets can be geographical, geopolitical or resultant from multi-party agreements similar to NAFTA or ASIAN.
			(Micro M)	**Ms**	Sub-Market 3	Sub-markets can be local or regional.
	I	Industries 4	(Macro I)	**I**	Industry 4	Industries are 'the organized action of making of goods and services for sale'. Industries can traverse markets and may be service, product or project-based. The AEC industry is mostly Project-Based. http://bit.ly/ielY3
			(Meso I)	**Is**	Sector 5	A sector is a "distinct subset of a market, society, industry, or economy whose components share similar characteristics" http://bit.ly/15UkZD
			(Micro I)	**Id**	Discipline 6	Disciplines are industry sectors, "branches of knowledge, systems of rules of conduct or methods of practice" http://bit.ly/7jT82
				Isp	Specialty 7	Specialty is a focus area of knowledge, expertise, production or service within a sub-discipline.
MESO Projects and their teams	**P**	Project Teams 8	n/a	**P**	Project Team 8	Project Teams are temporary groupings of organisations with the aim of fulfilling predefined objectives of a project - a planned endeavour, usually with a specific goal and accomplished in several steps or stages. http://bit.ly/dqMYg
MICRO Organisations, Units, their teams & members	**O**	Organisations 9	(Macro O)	**O**	Organisation 9	An organisation is a 'social arrangement which pursues collective goals, which controls its own performance, and which has a boundary separating it from its environment. http://bit.ly/v7p9N
			(Meso O)	**Ou**	Organisational Unit 10	Departments and Units are specialised divisions of an organisation. These can be co-located or distributed geographically.
				Ot	Organisational Team 11	Organisational Teams consist of a group of individuals (human resources) assigned to perform an activity or deliver a set of assigned objectives. Teams can be physically co-located or formed across geographical or departmental lines.
			(Micro O)	**Om**	Organisational Member 12	Organisational members can be part of multiple Organisational Teams.

Figure 16. Organizational scale units and characteristics (Succar, 2010).

3.2.3 Identification of Competency Granularity Levels

Four competency types are provided with BIM Maturity Matrix. These are discovery, evaluation, certification and audit. According to each competency area, the detail of the evaluation changes. These differences are illustrated in Figure 18. For instance, for discovery, it is enough to examine the competency sets. However, for evaluation, the research goes further than BIM competency areas, *i.e.*, to sub-

category of competency sets. As the competency type changing from discovery to auditing, the detail depth of the research is going be further. For certification and auditing, BIM Maturity Matrix starts to examine project specific information, an example of which is illustrated in Figure 17.

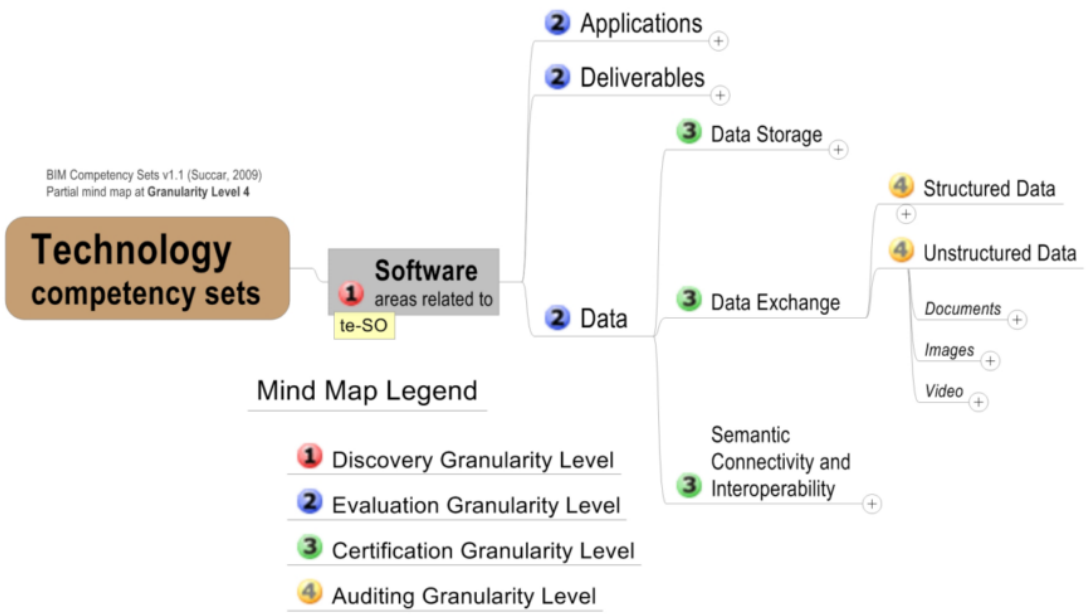


Figure 17. A sample illustration of differences of competency types from (1) Discovery, (2) Evaluation, (3) Certification, to (4) Auditing (Succar, 2010).

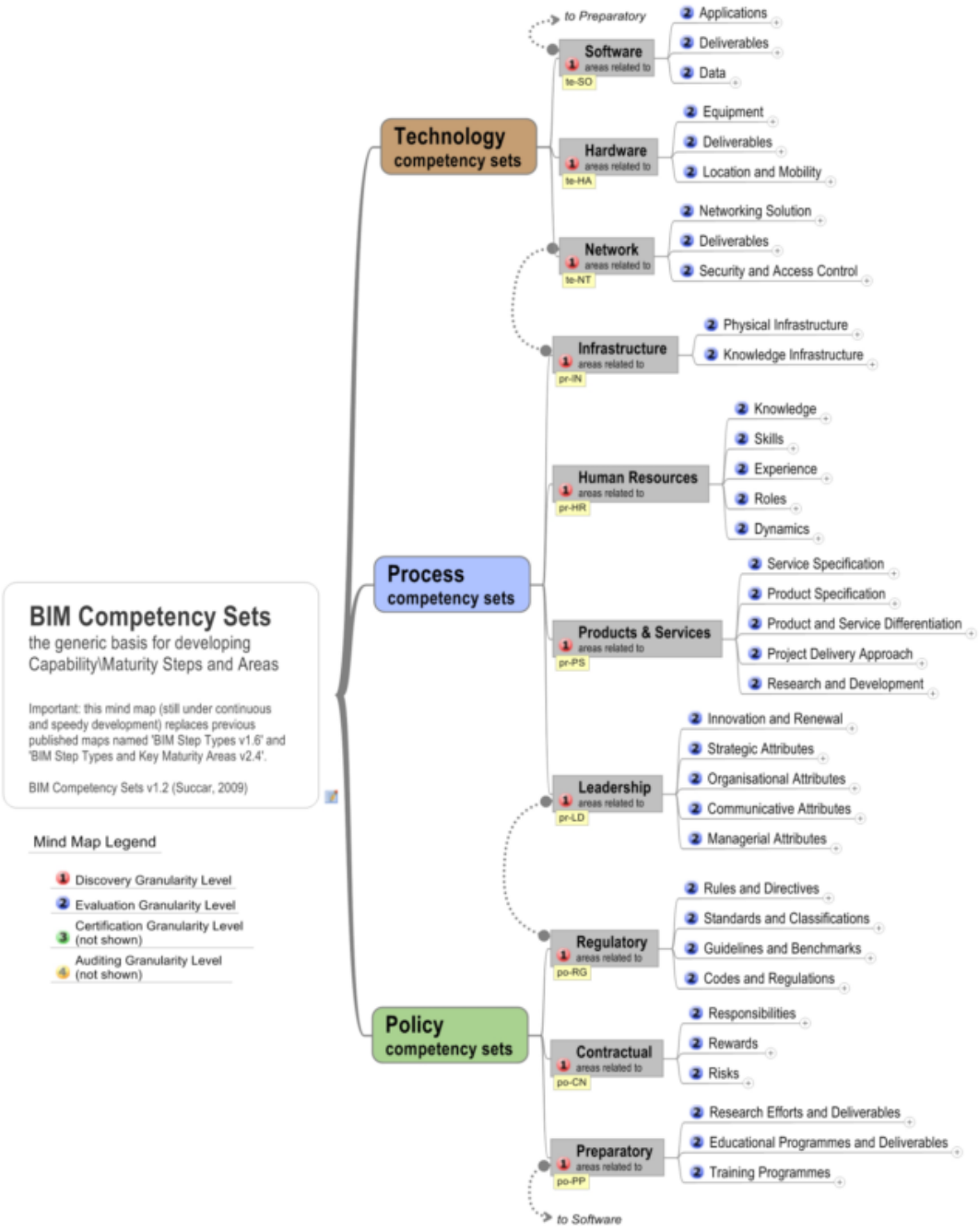


Figure 18. BIM competency granularity levels (Succar, 2010).

3.2.4 Detection of Capability Stages

Ability to perform a task, deliver a service or generate a product is described as BIM capability (Succar, 2010). Considering the NBIMS standards for products and services, minimum requirements are defined and BIM capability stages are established upon these minimum requirements (Succar, 2010). Before starting BIM maturity assessment, BIM stages of the firms have to be identified. Although this step is required by BIM Maturity Matrix (Succar, 2010), there is no relationship established between BIM competency areas and BIM capability stages. In other words, a firm in BIM capability stages 2 and another firm in BIM capability stages 3 could have same BIM maturity score. Therefore, it is not possible to compare the BIM performance of two firms having same BIM maturity score. This situation is a shortcoming of BIM Maturity Matrix that was argued and solved in BIM Quickscan, however; by benchmarking project specific data and information (Sebastian & Berlo, 2010). As explained in initial section of this chapter, the objectives of this study is not based on results collected from comparison of organizations' BIM performance and organization specific BIM characteristics. Therefore, it is not necessary to compare the BIM performance of the selected firms at the end of the assessment study. Instead, it is enough to collect and determine common characteristics of BIM performances of the firms.

Three capability stages utilized in BIM Maturity Matrix. These are (Succar, 2010):

- BIM Capability Stage 1: Object-Based Modeling
- BIM Capability Stage 2: Model-Based Collaboration
- BIM Capability Stage 3: Network-Based Integration

In the following sub-topics, the capability stages are explained based on the information provided by Succar (2010). Each capability stages draw the frame of

working practices and considering these explanations in each maturity level, the appropriate BIM maturity level is identified for each firm during the application of the assessment tool.

BIM Capability Stage 1: Object-Based Modeling

Users generate single-disciplinary models including only one of the project phases such as design, construction or operation. There is no collaboration effort in stage one. Data exchanges are uni-directional, communications are disjointed and there is still existing fragmentation of disciplines instead of integration, in other words, there are still existence of habits and clues of traditional (pre-BIM) working practices.

BIM Capability Stage 2: Model-Based Collaboration

Having developed their expertise in single-disciplinary model, the firm starts collaborative working practices with other disciplines. Model-based collaboration could occur including two phases such as design and construction, design and operation. Architecture and facility maintenance model interchanges could be example for design and operation phases. Some contractual arrangement is needed due to start of digital data transfer.

BIM Capability Stage 3: Network-Based Integration

At this capability stages, due to achievement of interdisciplinary collaboration in Stage 2, data rich integrated models are generated, shared and maintained collaboratively across project life-cycle phases. In order to achieve this goal, advanced technical infrastructure is needed. Models generated in stage 3 include other project life-cycle phases at early stages of design. The following advancement of this stage goes through integration and overlapping of phases, which at the end, business process transform to a phase-less process.

3.2.5 Detection of Maturity Levels

Following the detection of granularity competency type, it is time to perform the assessment. Considering their own working practices, the firms detect the maturity level of each competency area by comparing the indications of each level provided in tabular form of BIM Maturity Matrix with their working practices. In the following sub-sections, BIM Maturity Matrix competency areas are presented with respect to the competency sets.

BIM Competency Sets – Technology (Succar, 2010)

Table 10. Technology Competency Sets – Software maturity levels. Adopted from: (Succar, 2010)

Software: applications, deliverables and data	
Initial (a)	Usage of software applications is unmonitored and unregulated. 3D Models are relied on to mainly generate accurate 2D representations/deliverables. Data usage, storage and exchanges are not defined within organizations or project teams. Exchanges suffer from a severe lack of interoperability.
Defined (b)	Software usage/introduction is unified within an organization or project teams (multiple organizations). 3D Models are relied upon to generate 2D as well as 3D deliverables. Data usage, storage and exchange are well defined within organizations and project teams. Interoperable data exchanges are defined and prioritized.
Managed (c)	Software selection and usage is controlled and managed according to defined deliverables. Models are the basis for 3D views, 2D representations, quantification, specification and analytical studies. Data usage, storage and exchanges are monitored and controlled. Data flow is documented and well-managed. Interoperable data exchanges are mandated and closely monitored.
Integrated (d)	Software selection and deployment follows strategic objectives, not just operational requirements. Modelling deliverables are well synchronized across projects and tightly integrated with business processes. Interoperable data usage, storage and exchange are regulated and performed as part of an overall organizational or project-team strategy.
Optimized (e)	Selection/use of software tools is continuously revisited to enhance productivity and align with strategic objectives. Modelling deliverables are cyclically being revised/ optimized to benefit from new software functionalities and available extensions. All matters related to interoperable data usage storage and exchange are documented, controlled, reflected upon and proactively enhanced.

Table 11. Technology Competency Sets – Hardware maturity levels. Adopted from: (Succar, 2010)

Hardware: equipment, deliverables and location/mobility	
Initial (a)	BIM equipment is inadequate; specifications are too low or inconsistent across the organization. Equipment replacement or upgrades are treated as cost items and performed only when unavoidable.
Defined (b)	Equipment specifications – suitable for the delivery of BIM products and services - are defined, budgeted-for and standardized across the organization. Hardware replacements and upgrades are well-defined cost items.
Managed (c)	A strategy is in place to transparently document, manage and maintain BIM equipment. Investment in hardware is well-targeted to enhance staff mobility (where needed) and extend BIM productivity.
Integrated (d)	Equipment deployments are treated as BIM enablers. Investment in equipment is tightly integrated with financial plans, business strategies and performance objectives.
Optimized (e)	Existing equipment and innovative solutions are continuously tested, upgraded and deployed. BIM hardware become part of organization's or project team's competitive advantage.

Table 12. Technology Competency Sets – Network maturity levels. Adopted from: (Succar, 2010)

Network: solutions, deliverables and security/ access control	
Initial (a)	Network solutions are non-existent or ad-hoc. Individuals, organizations (single location/ dispersed) and project teams use whatever tools found to communicate and share data. Stakeholders lack the network infrastructure necessary to harvest, store and share knowledge.
Defined (b)	Network solutions for sharing information and controlling access are identified within and between organizations. At project level, stakeholders identify their requirements for sharing data/information. Dispersed organizations and project teams are connected through relatively low-bandwidth connections.
Managed (c)	Network solutions for harvesting, storing and sharing knowledge within and between organizations are well managed through common platforms (e.g. intranets or extranets). Content and asset management tools are deployed to regulate structured and unstructured data shared across high-bandwidth connections.
Integrated (d)	Network solutions enable multiple facets of the BIM process to be integrated through seamless real-time sharing of data, information and knowledge. Solutions include project-specific networks/portals which enable data-intensive interchange (interoperable exchange) between stakeholders.
Optimized (e)	Network solutions are continuously assessed and replaced by the latest tested innovations. Networks facilitate knowledge acquisition, storing and sharing between all stakeholders. Optimization of integrated data, process and communication channels is relentless.

BIM Competency Sets – Processes (Succar, 2010)

Table 13. Process Competency Sets – Infrastructure maturity levels. Adopted from: (Succar, 2010)

Infrastructure: Physical and knowledge-related	
Initial (a)	The work environment is either not recognized as a factor in staff satisfaction or may not be conducive to productivity. Knowledge is not recognized as an asset; BIM knowledge is typically shared informally between staff (through tips, techniques and lessons learned).
Defined (b)	The work environment and workplace tools are identified as factors affecting motivation and productivity. Similarly, knowledge is recognized as an asset; shared knowledge is harvested, documented and thus transferred from tacit to explicit.
Managed (c)	The work environment is controlled, modified and it's criteria managed to enhance staff motivation, satisfaction and productivity. Documented knowledge is also adequately stored.
Integrated (d)	Environmental factors are integrated into performance strategies. Knowledge is integrated into organizational systems; stored knowledge is made accessible and easily retrievable [refer to the 4 levels of knowledge retention (Arif et al., 2009)].
Optimized (e)	Physical workplace factors are reviewed constantly to insure staff satisfaction and an environment conducive to productivity. Similarly, knowledge structures responsible for acquisition, representation and dissemination are systematically reviewed and enhanced.

Table 14. Process Competency Sets – Products and Services maturity levels. Adopted from: (Succar, 2010)

Products & Services: specification, differentiation, project delivery approach and Research & Development	
Initial (a)	3D models deliverables (a BIM product) suffer from too high, too low or inconsistent levels of detail.
Defined (b)	A "statement defining the object breakdown of the 3D model" (Bouygues, 2007) is available.
Managed (c)	Adoption of product/ service specifications similar to Model Progression Specifications (AIA, 2008), BIPS „information levels" (BIPS, 2008) or similar.
Integrated (d)	Products and services are specified and differentiated according to Model Progression Specifications or similar.
Optimized (e)	BIM products and services are constantly evaluated; feedback loops promote continuous improvement.

Table 15. Process Competency Sets – Human Resources maturity levels. Adopted from: (Succar, 2010)

Human Resources: competencies, roles, experience and dynamics	
Initial (a)	There is an absence of defined processes; roles are ambiguous and team structures/dynamics are inconsistent. Performance is unpredictable and productivity depends on individual heroics. A mentality of "working around the system" flourishes.
Defined (b)	BIM roles are informally defined and teams are formed accordingly. Each BIM project is planned independently. BIM competency is identified and targeted; BIM heroism fades as competency increases but productivity is still unpredictable.
Managed (c)	Cooperation within organizations increases as tools for cross-project communication are made available. Flow of information steadies; BIM roles are visible and targets are achieved more consistently.
Integrated (d)	BIM roles and competency targets are imbedded within the organization. Traditional teams are replaced by BIM-oriented ones as new processes become part of organization's / project team's culture. Productivity is now consist
Optimized (e)	BIM competency targets are continuously upgraded to match technological advances and align with organizational objectives. Human resource practices are proactively reviewed to insure intellectual capital matches process needs.

Table 16. Process Competency Sets – Leadership maturity levels. Adopted from: (Succar, 2010)

Leadership: innovation and renewal, strategic, organizational, communicative and managerial attributes	
Initial (a)	Senior leaders/ managers have varied visions about BIM. BIM implementation (according to BIM Stage requirements) is conducted without a guiding strategy. At this maturity level, BIM is treated as a technology stream; innovation is not recognized as an independent value and business opportunities arising from BIM are not acknowledged.
Defined (b)	Senior leaders/managers adopt a common vision about BIM. BIM implementation strategy lacks actionable details. BIM is treated as a process-changing, technology stream. Product and process innovations are recognized; business opportunities arising from BIM are identified but not exploited.

Table 16. *Continuing*

Managed (c)	The vision to implement BIM is communicated and understood by most staff. BIM implementation strategy is coupled with detailed action plans and a monitoring regime. BIM is acknowledged as a series of technology, process and policy changes which need to be managed without hampering innovation. Business opportunities arising from BIM are acknowledged and used in marketing efforts.
Integrated (d)	The vision is shared by staff across the organization and/or project partners. BIM implementation, its requirements and process/ product innovation are integrated into organizational, strategic, managerial and communicative channels. Business opportunities arising from BIM are part of team, organization or project-team's competitive advantage and are used to attract and keep clients.
Optimized (e)	Stakeholders have internalized the BIM vision and are actively achieving it (Nightingale & Mize, 2002). BIM implementation strategy and its effects on organizational models are continuously revisited and realigned with other strategies. If alterations are needed, they are proactively implemented. Innovative product/ process solutions and business opportunities are sought-after and followed through relentlessly.

BIM Competency Sets – Policy (Succar, 2010)

Table 17. Process Competency Sets – Regulatory maturity levels. Adopted from: (Succar, 2010)

Regulatory: rules/ directives, standards/ classifications, guidelines/ benchmarks	
Initial (a)	There are no BIM guidelines, documentation protocols or modelling standards. There is an absence of documentation and modelling standards. There is informal or no quality control plans; neither for 3D models nor for documentation. There are no performance benchmarks for processes, products or services.
Defined (b)	Basic BIM guidelines are available (e.g. training manual and BIM delivery standards). Modelling and documentation standards are well defined according to market-accepted standards. Quality targets and performance benchmarks are set.
Managed (c)	Detailed BIM guidelines are available (training, standards, workflow, exceptions...). Modelling, representation, quantification, specifications and analytical properties of 3D models are managed through detailed modelling standards and quality plans. Performance against benchmarks is tightly monitored and controlled.
Integrated (d)	BIM guidelines are integrated into overall policies and business strategies. BIM standards and performance benchmarks are incorporated into quality management and performance improvement systems.
Optimized (e)	BIM guidelines are continuously and proactively refined to reflect lessons learned and industry best practices. Quality improvement and adherence to regulations and codes are continuously aligned and refined. Benchmarks are repetitively revisited to insure highest possible quality in processes, products and services

Table 18. Process Competency Sets – Contractual maturity levels. Adopted from: (Succar, 2010)

Contractual: responsibilities, rewards and risks	
Initial (a)	Dependence on pre-BIM contractual arrangements. BIM risks related to model-based collaboration (differ in each market) are not recognized or are ignored.
Defined (b)	BIM requirements are recognized. "Statements defining the responsibility of each stakeholder regarding information management" (Bouygues, 2007) are now available.
Managed (c)	There is a mechanism to manage shared BIM intellectual property, confidentiality, liability and a system for BIM conflict resolution.
Integrated (d)	Organization are aligned through trust and mutual dependency beyond contractual barriers.
Optimized (e)	Responsibilities, risks and rewards are continuously revisited and realigned to effort. Contractual model are modified to achieve best practices and highest value for all stakeholders.

Table 19. Process Competency Sets – Preparatory maturity levels. Adopted from: (Succar, 2010)

Preparatory: research efforts/ deliverables, educational programs/ deliverables and training programs	
Initial (a)	Very little or no training available to BIM staff. Educational/ training mediums are not suitable to achieve the results sought.
Defined (b)	Training requirements are defined and are typically provided only when needed. Training mediums are varied allowing flexibility in content delivery.
Managed (c)	Training requirements are managed to adhere to pre-set broad competency and performance objectives. Training mediums are tailored to suit trainees and reach learning objectives in a cost-effective manner.
Integrated (d)	Training is integrated into organizational strategies and performance targets. Training is typically based on staff roles and respective competency objectives. Training mediums are incorporated into knowledge and communication channels.
Optimized (e)	Training is continuously evaluated and improved upon. Training availability and delivery methods are tailored to allow multi-modal continuous learning.

3.2.6 Results

After detection of maturity areas, although it is open to new expression types to demonstrate the evaluation results (Succar, 2010), both diagrammatic illustration and BIM maturity score are provided in this study. Sample representations are illustrated in Figure 19 and Figure 20.

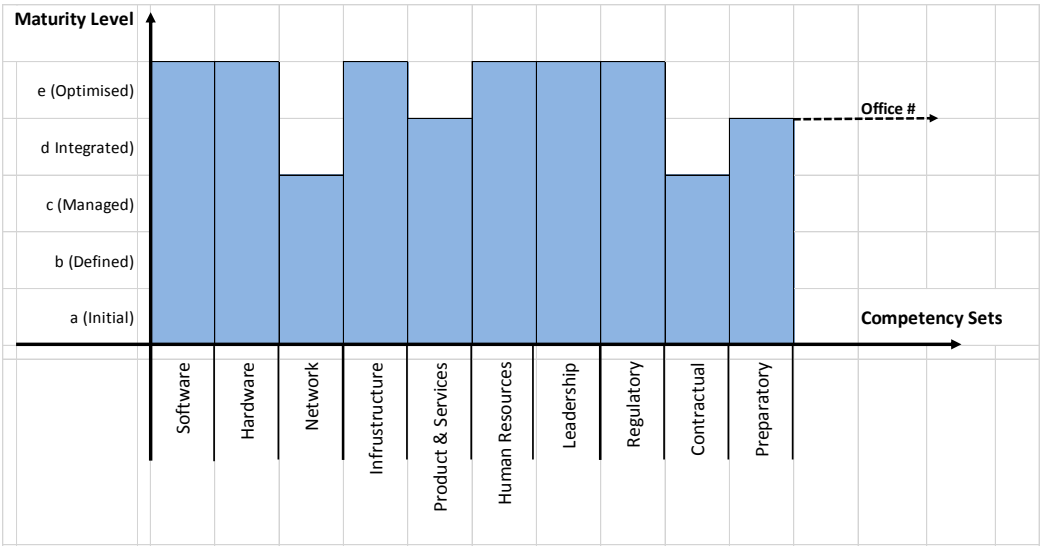


Figure 19. Diagrammatic illustration of the maturity levels

Maturity Discovery Score						
BIM Maturity Matrix Assessment at Granularity Level 1		a 10 points	b 20 points	c 30 points	d 40 points	e 50 points
Technology	Software					●
	Hardware					●
	Network			●		
Process	Infrustructure					●
	Products & Services				●	
	Human Resources					●
	Leadership					●
Policy	Regulatory				●	
	Contractual			●		
	Preparatory					●
Stage	Modeling-Based Collaboration		●			
Scale	Organizational Unit (10)					●
Subtotal			20	60	80	350
Total Points						510
Maturity Score						**42,50**

Figure 20. BIM maturity discovery score

3.3 Sample Firms Used in BIM Maturity Assessment

At the initial phases of this study instead of making a BIM maturity assessment to benchmark the capabilities of Turkish architecture and engineering firms BIM implementation, a survey was conducted. By the help of Chamber of Architects of Turkey, an online survey invitation was sent to approximately 100 architecture firms. 20 of them participated and 15 of them fully completed the survey. The results of this survey found unsatisfactory to make further analysis and discussion related with BIM implementation in Turkey. Therefore, by changing the research methodology from online survey to BIM maturity assessment study and experienced lessons during the survey, second invitation e-mail was sent to these 15 firms. Seven of them accepted the invitation whose characteristics are presented in Table 21.

The selected firms has a variety of market, location and organizational characteristics; allowing finding out common awards and handicaps of BIM maturity assessment.

Enterprise category was determined according to the KOSGEP definition of SMEs depicted in Table 20. KOSGEP is the official institution for development and support of Small-Medium Enterprises (SMEs) in Turkey (KOSGEP, 2012). On the other hand, the KOSGEP definition asks for annual turnover and balance sheet from the firms, which are private data for the firms that most of them were reluctant to share during the assessment study. Therefore, only the number of employee considered as criteria on detection of enterprise category of the participating firms.

Table 20. KOSGEP classification of enterprises. Source: (KOSGEP, 2012)

Scale	Number of Employees	Annual Turnover (TL)	Balance Sheet (TL)
Micro	<10	≤1 Million	≤1 Million
Small	<50	≤5 Million	≤5 Million
Medium	<250	≤25 Million	≤25 Million

Office #1, #2 and #3 are located in Antalya. The most of their services are in Antalya and nearby cities. Office #4 and #5 are located in Ankara. Office #4 is mostly active in Ankara and other cities in Tukey. Office #5 has one branch office in Northern Iraq, therefore; active in not only Turkey but also Iraq and nearby Middle Eastern countries. Office #6 and Office #7 are located in Istanbul. Office #6 is an engineering firm and unique among others in this regard. Both Office #6 and Office #7 are active not only in Turkey but also in international market.

Table 21. Information about the firms conducted in BIM maturity research

	Working Field	**Enterprise Category**	**Location**
Office #1	Architectural Design	Micro	Antalya
Office #2	Architectural Design	Small	Antalya
Office #3	Architectural Design	Small	Antalya
Office #4	Architectural Design	Small	Ankara
Office #5	Architecture and Engineering Design	Small	Ankara
Office #6	Engineering Design	Small	Istanbul
Office #7	Architectural Design	Medium	Istanbul

3.4 Application of BIM Maturity Assessment

The nature of BIM maturity matrix assessment requires explanation and understanding of each assessment sections and areas to the participant firm. Therefore, by firstly explaining the each maturity field, area and level, the clear understanding of BIM maturity assessment were provided to the participant firm. Then their applications and practices related with the each maturity area are asked to the firm and their explanations and experiences were noted to clearly detect the maturity of the firm. This means that taken notes represent the actions and applications of the participant firm about assessed BIM maturity areas. Furthermore, taken notes representing the participant firm actions and practices in related maturity area could be compared with original explanations, which were always referenced during the presentation in this study to enable comparison of collected data and original given data by BIM Maturity Matrix

3.4.1 BIM Maturity Assessment of Office #1

The firm has implemented BIM practices since two years with the employment of a 10 year experienced BIM manager. The firm has nine employees. In the following sub-topics, BIM maturity assessment of Office #1 is studied in compliance with the BIM maturity assessment procedure.

Identification of Organizational Scale

Beside architectural services, the firm also provide interior architectural services to their clients, therefore, not all of the staff practicing in BIM concept. 5 of the 9

personnel gives BIM services, therefore; it is clear that there is a departmentalization inside the organization that one group provide architectural services and other group provides interior architectural services. Therefore, in these working conditions, organizational scale is accepted as "organizational team (11)" with respect to categorization presented in Figure 16.

Detection of Capability Stages

Table 22. Capability Stage of Office #1

BIM Capability Stage		Maturity Level	Explanation of Maturity Level	Taken Notes
Stage-1	**Object-Based Modeling**	**Defined (b)**	Pilot projects are concluded. BIM process and policy requirements are identified. Implementation strategy and detailed plans are prepared.	Completion of pilot projects enabled seeing the capabilities of staff. Considering the market conditions, client and other project participants' attitude, further BIM implementation strategy and plans are prepared and agreed upon.

Detection of Maturity Levels

Table 23. Technology Competency Sets of Office #1

		Maturity Level	Taken Notes
Technology	**Software**	**Defined (b)** See Table 10 for Explanations	The software selection is done according to the deliverables. Models are the basis for 3D views, 2D representations, quantification and specifications. Data usage, storage and exchanges are well defined inside the organization but not documented and monitored. Furthermore, there is no interoperable data exchanges

Table 23. *Continuing*

	Hardware	**Defined (b)** See Table 11 for Explanations	The hardware investment is a part of annual budget of the firm and necessary upgrades are regularly followed. However, there is no documented strategy to follow and manage these cost items. Hardware capabilities are set to provide advanced modeling services.
	Network	**Initial (a)** See Table 12 for Explanations	Network solutions could be accepted as ad-hoc level. The computers in the organizations were connected to each other via wireless internet service provider modem. A common sharing documents enabled via this wireless modem that one of the computer was accepted as central depository. The wireless network modem is inadequate to support all of the devices inside the office. Therefore, there was routine disconnection to internet among the computers. The firm has an e-mail defined on one of the free e-mail service providers. This e-mail could be used as file transfer tool between project participants or other project related parties. Every employee had a flash disk to share larger sized files among project participants. Therefore, there is no network solution specific for this firm to share, harvest and store knowledge among both project participants and stakeholders.

Table 24. Process Competency Sets of Office #1

		Maturity Level	**Taken Notes**
Process	**Infrastructure**	**Defined (b)** See Table 13 for Explanations	Current working environment created by the owner of the firm could be accepted as neither could be specified as based on staff satisfaction, nor related with productivity. However, the owner of the firm is sensitive to staff demands on personality and privatization of working environment. Therefore, this situation affects the comfort and moral factor of the employees. Knowledge is recognized as an asset. BIM knowledge is shared in regular performance meetings at weekend and each staff share their experiences and learned tips. However, although this knowledge are documented during the meetings, they are not stored in long term periods.
	Products & Services	**Initial (a)** See Table 14 for Explanations	There is no standard related with product and services. Considering the necessary services and products in weekly schedule, work and delivery schedule is prepared and executed as long as possible. There is no modeling standard utilized in the practices.
	Human Resource	**Defined (b)** See Table 15 for Explanations	The firm experiences the given explanation in this maturity area completely.

Table 24. *Continuing*

	Leadership	**Integrated (d)** See Table 16 for Explanations	There is a common vision about BIM implementation and this is shared throughout whole organization. The firm tries to develop their working practices in compliance with the BIM concept as long as possible but staying in the limits of available market conditions. Completed projects are used as a reference for new job opportunities and completed projects are also used for creating BIM awareness among other project participants.

Table 25. Policy Competency Sets of Office #1

		Maturity Level	**Taken Notes**
Policy	**Regulatory**	**Initial (a)** See Table 17 for Explanations	The explanation of maturity level completely illustrate the situation that the firm suffer from.
	Contractual	**Initial (a)** See Table 18 for Explanations	As stated in the explanation, there are still dependence of pre-BIM contractual arrangements. There is no indication related with BIM in the agreements. The BIM is only a tool that accelerate the available product and services.
	Preparatory	**Managed (c)** See Table 19 for Explanations	Training is a part of organization objectives but there are still no performance targets. Furthermore, there is no role and responsibility differentiation in training. Training and learning items are trying to be achieved in a cost-effective manner as long as possible.

Results and Discussion

Both diagrammatic and score result of Office #1 are presented in Figure 21 and 22. Due to non-existence of policy background of BIM in Antalya, the working practices are still in a transition period. No guidance or best practice document is followed during the implementation. The firm try to adopt new features of BIM as long as possible inside their organizations. The budget of software investment is constant and integrated with organization annual budget. There is also a strong intention to implement BIM practices in the firm. However, there are so many

weaknesses in network, product and services, contracts, and regulatory areas. Lack of technical support, and weak network infrastructure provided in Turkey are causes of low network maturity.

Considering those circumstances, both diagrammatic and score result of BIM maturity assessment of Office #1 is demonstrated as Figure 21 and Figure 22.

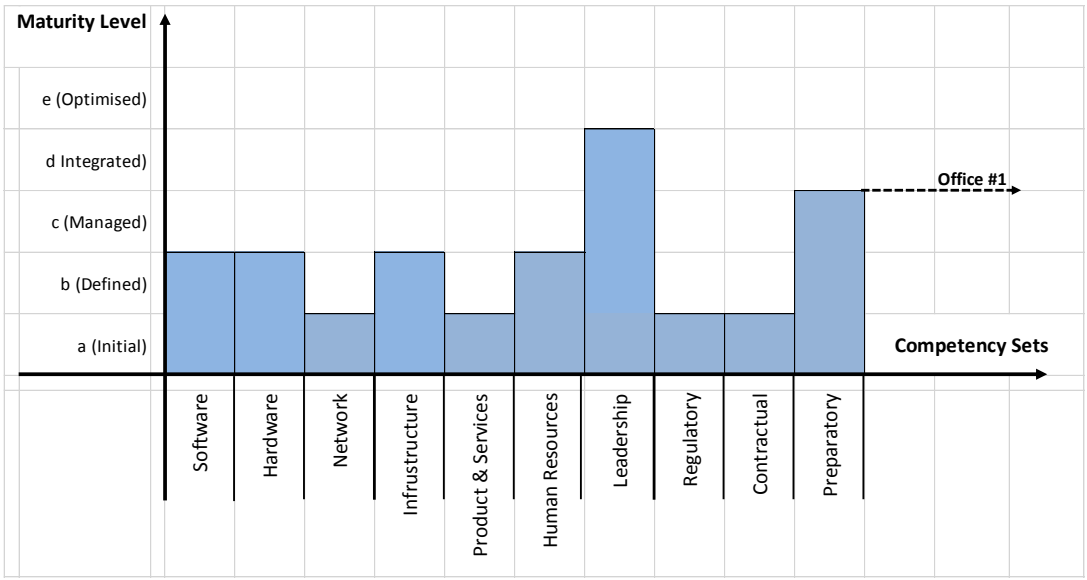


Figure 21. Diagrammatic expression of BIM maturity assessment result of Office #1

BIM Maturity Assessment for Office #1		a	b	c	d	e
		10 points	20 points	30 points	40 points	50 points
Technology	Software		●			
	Hardware		●			
	Network	●				
Process	Infrustructure		●			
	Products & Services	●				
	Human Resources		●			
	Leadership				●	
Policy	Regulatory	●				
	Contractual	●				
	Preparatory			●		
Stage	Object-Base Modeling		●			
Scale	Organizational Team (11)			●		
Subtotal		40	100	60	40	
Total Points						240
Maturity Score						**20.00**

Figure 22. BIM maturity score of Office #1

3.4.2 BIM Maturity Assessment of Office #2

This architectural design firm is located at Antalya and one of the best-known architecture firm in Antalya. The firm has six employees. The BIM manager of the firm stated that BIM tools has been actively used in the projects for four years. Considering these statements, BIM maturity assessment of Office #2 is presented as follows.

Identification of Organizational Scale

Employment of BIM personnel varied since the BIM implementation started and when this assessment study was conducted, only personnel in the office was the BIM manager responsible for BIM practice. Therefore, in this study only the BIM performance that executed by BIM manager has been assessed. Thus considering

the statements illustrated in Figure 16, organizational scale is accepted as "organizational member".

Detection of Capability Stages

Table 26. Capability Stage of Office #2

BIM Capability Stage		Maturity Level	Explanation of Maturity Level	Taken Notes
Stage-1	**Object-Based Modeling**	**Initial (a)**	Implementation of an object-based tool. No process or policy changes identified to accompany this implementation.	There was no process and policy change in the overall firm's usual working practices due to BIM implementation. The BIM practices took place inside current working practices without changing the overall and usual working process. Instead of changing the traditional process, the BIM concept take a place partially.

Detection of Maturity Levels

Table 27. Technology Competency Sets of Office #2

		Maturity Level	Taken Notes
Technology	**Software**	**Initial(a)** See Table 10 for Explanations	The usage of software is only to generate accurate 3-D models and 2-D representations and deliverables. No other usage is available in this organization.
	Hardware	**Defined (b)** See Table 11 for Explanations	The necessary budget for hardware to provide accurate 3-D model and 2-D deliverables are defined and regularly updated in order not to suffer from inadequate hardware solutions during the modeling process.

Table 27. *Continuing*

	Network	**Managed (c)** See Table 12 for Explanations	Network solutions for harvesting, storing and sharing knowledge within the organization was provided by a central server (intranet). This system includes only the users inside the office. It was not possible to access the central server from outside the organization. However, this intranet system is not developed for and transformed to work with BIM. The available solution is adopted for continuing the traditional process in which, 3-D models and 2-D drawings are stored and shared to other users inside the organization.

Table 28. Process Competency Sets of Office #2

		Maturity Level	**Taken Notes**
Process	**Infrastructure**	**Initial (a)** See Table 13 for Explanations	There was a defined working environment created by the owner of the firm neither could be specified as based on staff satisfaction, nor related with productivity. The environment reflects the architectural reflection and design idea of the firm mostly, rather than comfort and moral factor for employees.
	Products & Services	**Initial (a)** See Table 14 for Explanations	The generated model produced only for generation of accurate 2-D drawings and views. Therefore BIM products suffer from inconsistent level of detail generated for deliverables of traditional working practices.
	Human Resource	**Initial (a)** See Table 15 for Explanations	Total number of BIM staff has varied since the BIM implementation started. There is problem on consistent employment of BIM staff. Each BIM project is planned independently. BIM competency was identified only including the inner organization and each project was modeled accordingly.
	Leadership	**Initial (a)** See Table 16 for Explanations	Owner of the firm has still doubt about complete adoption of BIM. Considering the statements of BIM manager, both market conditions and available clients do not encourage a complete BIM adoption. Combining these conditions with lack of consistent employment of BIM staff, it is even hard to observe the indications of this maturity level.

Table 29. Policy Competency Sets of Office #2

		Maturity Level	Taken Notes
Policy	**Regulatory**	**Initial (a)** See Table 17 for Explanations	The explanation of maturity level completely illustrate the situation that the firm suffers from.
	Contractual	**Initial (a)** See Table 18 for Explanations	As stated in the explanation, there are still dependence of pre-BIM contractual arrangements. There is no indication related with BIM in the agreements. The BIM is only a tool that accelerate the generation of available product and services
	Preparatory	**Defined (b)** See Table 19 for Explanations	There is a defined training content to BIM staff in comply with the overall process and products of the firm.

Results and Discussion

Although the firm has four years of BIM experience, there are no advances observed. As indicated in the assessment notes, there are various factors for the firm for not advancing in BIM adoption. Firstly, the owner of the firm does not have a consistent BIM adoption vision to execute. Secondly, the firm has experienced disappointments on BIM adoption due to various factors such as the firm is unable to employ BIM staff consistently. Thirdly, the available market conditions of the firm are not encouraging the firm for full adoption of BIM. Therefore, it was observed that BIM adoption did not change the current working practices of the firm. The BIM practices became a part of the available working practices. Therefore, rather than expecting the changes in the current working practices, in this firm, due to the vision of the owner of the design firm, BIM adoption stayed as a part of the current practices. The BIM manager stated that in initial phases, BIM training among the office started with three persons, on the

other hand; these persons could not continue their employment until finish the training. Thus, considering these facts, owner of the firm changed his attitude towards BIM transition and gave up changing the existing working process completely. As a result, BIM concept took a seat in existing working practices and met some of the deliverable needs. As a result of these conditions, the firm showed very low BIM maturity performance as illustrated in Figure 23 and 24.

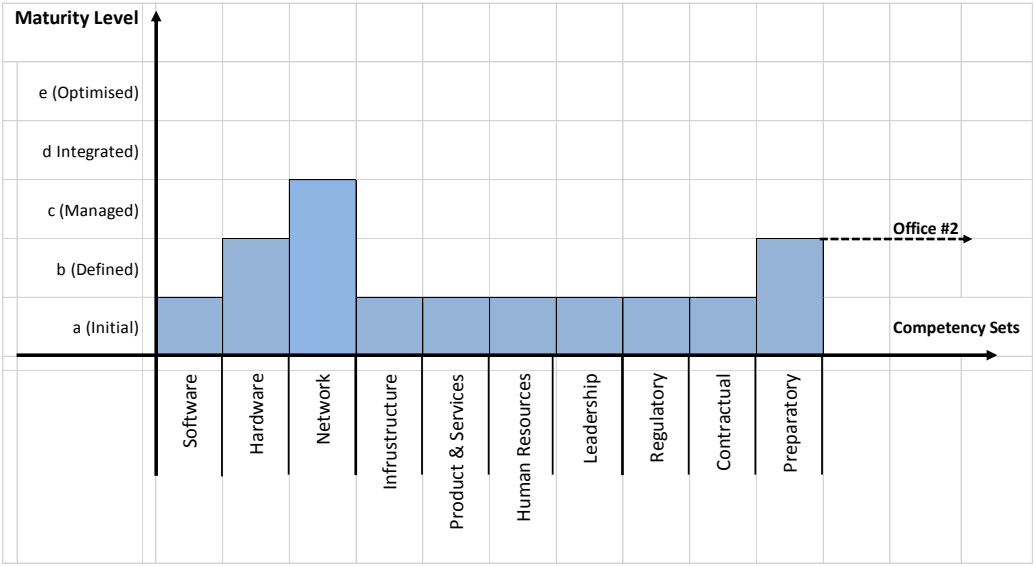


Figure 23 Diagrammatic expression of BIM maturity assessment result of Office #2

BIM Maturity Assessment for Office #2		a	b	c	d	e
		10 points	20 points	30 points	40 points	50 points
Technology	Software	●				
	Hardware		●			
	Network			●		
Process	Infrustructure	●				
	Products & Services	●				
	Human Resources	●				
	Leadership	●				
Policy	Regulatory	●				
	Contractual	●				
	Preparatory		●			
Stage	Object-Base Modeling	●				
Scale	Organizational Member (12)		●			
Subtotal		80	60	30		
Total Points						170
Maturity Score						**14.16**

Figure 24 BIM maturity score of Office #2

3.4.3 BIM Maturity Assessment of Office #3

This office is one of the third office that actively use BIM tools in their working process which is located in Antalya when this study was conducted. The firm has 12 employees and all of them work with BIM concept. Considering these circumstances, BIM maturity assessment of office #3 was conducted as follows.

Identification of Organizational Scale

All of the technical staff are working in BIM concept. Therefore, considering the statements in Figure 16, "organization (9)" is accepted as organizational scale.

Detection of Capability Stages

Table 30. Capability Stage of Office #3

BIM Capability Stage		Maturity Level	Explanation of Maturity Level	Taken Notes
Stage-1	**Object-Based Modeling**	**Integrated (d)**	BIM technologies, processes and policies are integrated into organizational strategies and aligned with business objectives.	Beside the firm experiencing the indications of this maturity level, the firm is in avant-garde one in Antalya in BIM transition.

Detection of Maturity Levels

Table 31. Technology Competency Sets of Office #3

		Maturity Level	Taken Notes
Technology	**Software**	**Managed (c)** See Table 10 for Explanations	The models are basis for not only 3-D and 2-D deliverables but also quantifications, specification and cost estimations. Data usage, storage and exchanges are controlled and documented.
	Hardware	**Optimized (e)** See Table 11 for Explanations	The firm owner and BIM manager continuously test and follow upgrades. BIM hardware is a part of firm's competitive advantages.
	Network	**Managed (c)** See Table 12 for Explanations	Network solutions for harvesting, storing and sharing knowledge within the organization was provided by a central server (intranet). This system includes only the users inside the office. It was not possible to access the central server from outside the organization.

Table 32. Process Competency Sets of Office #3

		Maturity Level	Taken Notes
Process	**Infrastructure**	**Optimized (e)** See Table 13 for Explanations	Physical workplace is set for comfort and productivity of the staff. Every working practice is continuously reviewed and revised in weekly meetings.
	Products & Services	**Initial (a)** See Table 14 for Explanations	Although firm expresses high BIM maturity in some areas, there is no accepted and applied BIM standard for deliverables. Based on the current needs in usual practices, deliverables are prepared. Mostly, like other firms, services and deliverables are set in compliance with project phases and deliverables described in architectural service specifications of Chamber of Architects of Turkey (CAT).
	Human Resource	**Defined (b)** See Table 15 for Explanations	Total number of BIM staff has varied since the BIM implementation started. There is problem of consistent employment of BIM staff. Each BIM project is planned independently. BIM competency was identified only inside the organization and each project is developed accordingly.

Table 32. *Continuing*

	Leadership	**Optimized (e)** See Table 16 for Explanations	Owner of the firm is so much interested in innovative solutions. Therefore, he maintains BIM adoption himself in his firm. Whole staff accepted and applied new working practices and in every meeting conducted at weekend, all of the procedure and practices are reviewed and replaced with new solutions in case of necessity.

Table 33. Policy Competency Sets of Office #3

		Maturity Level	**Taken Notes**
Policy	**Regulatory**	**Initial (a)** See Table 17 for Explanations	There is a standard BIM training for new employees and there are also guidelines for BIM deliverables developed according to the firm organizational strategies. However, these are not in compliance with any standard or official document.
	Contractual	**Initial (a)** See Table 18 for Explanations	Although firm express high BIM maturity performance in some areas, there is still dependence on pre-BIM contractual arrangements. There is no indication related with BIM in the agreements.
	Preparatory	**Managed (c)** See Table 19 for Explanations	There is a defined training content for BIM staff to comply with the overall process and products of the firm. The training is provided by the experienced staff. Upgrades and new tools are presented by either firm owner or consultants in a cost effective way.

Results and Discussion

The owner of the firm actively controls and directs the BIM adoption process. The firm has started the BIM transition five years ago. BIM transition process includes whole staff in the firm. All of the projects were started, developed and finished in BIM environment. Furthermore, the firm removed hard copy deliverables in construction phase of the project. A mobile model viewing system has been initiated one year ago and results were satisfactory for the firm and for other project participants according to the statements of firm BIM manager. The firm insists on

sustaining the BIM transition process. As a result of this situation, the firm had achieved creating a BIM based culture among other project participants and firm was known with its innovative and BIM based solutions among its market. After BIM adoption, the firm made a tradition of arranging weekly performance measurements meetings and the working process was periodically reviewed and updated with new solutions and proposals. There are also a pre-planned standard training and guidelines for new employees to teach the firm standards about BIM deliverables. However, these documents are not based on any official BIM documents. Furthermore, there is no accepted official BIM standards or guide utilized in the firm. Considering these statements, BIM maturity assessment results of the firm are presented in Figure 25 and 26.

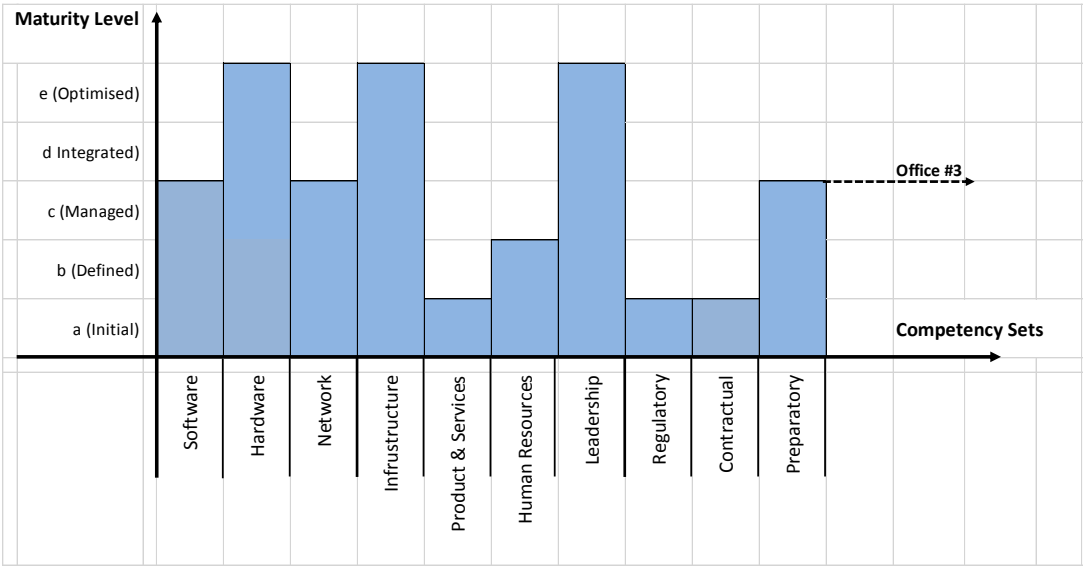


Figure 25. Diagrammatic expression of BIM maturity assessment result of Office #3

BIM Maturity Assessment for Office #3		a	b	c	d	e
		10 points	20 points	30 points	40 points	50 points
Technology	Software			●		
	Hardware					●
	Network			●		
Process	Infrustructure					●
	Products & Services	●				
	Human Resources		●			
	Leadership					●
Policy	Regulatory	●				
	Contractual	●				
	Preparatory			●		
Stage	Object-Base Modeling				●	
Scale	Organization (9)					●
Subtotal		30	20	90	40	200
Total Points						380
Maturity Score						**31.60**

Figure 26. BIM maturity score of Office #3

3.4.4 BIM Maturity Assessment of Office #4

This architectural design firm has two offices in Turkey. One of the branches is located in Ankara and the other one is located in Istanbul. All of the 11 design staff are working with BIM concept. The assessment was conducted with the owner of the firm. The owner of the firm stated that the firm applied BIM concept completely in its organizational scale, on the other hand; model-based collaboration and network-based integration could not have been achieved yet. The firm had been used actively BIM tools since 2011.

Identification of Organizational Scale

The whole design staff worked in BIM concept, therefore, considering the statements in Figure 16, “organization (9)” is accepted as organizational scale.

Detection of Capability Stages

Table 34. Capability Stages of Office #4

BIM Capability Stage		Maturity Level	Explanation of Maturity Level	Taken Notes
Stage-1	**Object-Based Modeling**	**Integrated (d)**	BIM technologies, processes and policies are integrated into organizational strategies and aligned with business objectives.	The firm work in object-based modeling stage. Further advanced stages were not achieved yet. Although having two offices could enable collaborative and integrated working practices, the firm stated that both technical capacity and network infrastructure are inadequate to experience these practices.

Detection of Maturity Levels

Table 35. Technology Competency Sets of Office #4

		Maturity Level	Taken Notes
Technology	**Software**	**Managed (c)** See Table 10 for Explanations	Software selection is done for operational requirements. Models are basis for not only 2-D and 3-D deliverables but also for quantification, specification and analytical studies. However, maintaining those practices has not become part of the organizational objectives yet.
	Hardware	**Managed (c)** See Table 11 for Explanations	Cost of upgrades and new solutions are well-targeted cost items and part of organization usual budget. The strategy is "applying those upgrades and solutions as soon as possible". However, it is still not integrated with organization objectives.
	Network	**Managed (c)** See Table 12 for Explanations	There is central server in each office. These servers are not connected to each other. Each user could harvest, store and share knowledge within organization and within office by established network on these servers

Table 36. Policy Competency Sets of Office #3

		Maturity Level	Taken Notes
Process	**Infrastructure**	**Optimized (e)** See Table 13 for Explanations	Physical workplace is set for comfort and productivity of the staff. Every working practice is continuously reviewed and revised in weekly meetings.
	Products & Services	**Initial (a)** See Table 14 for Explanations	Although firm express high BIM maturity in some areas, there is no accepted and applied BIM standard for deliverables. Based on the current needs in usual practices, deliverables are prepared. Mostly, like other firms, services and deliverables are set in compliance with project phases and deliverables described in architectural service specifications of Chamber of Architects of Turkey (CAT)
	Human Resource	**Optimized (e)** See Table 15 for Explanations	The BIM implementation is a part of the organization practice and not only aligned with organizational objectives but also has become a competitive characteristic for the firm.
	Leadership	**Optimized (e)** See Table 16 for Explanations	The firm actively experiences these maturity level indications.

Table 37. Policy Competency Sets of Office #3

		Maturity Level	Taken Notes
Policy	**Regulatory**	**Initial (a)** See Table 17 for Explanations	There is a standard BIM training for new employees and there are also guidelines for BIM deliverables. BIM services are set considering the market needs and organizational strategies, therefore; modeling and documentation standards are prepared in accordance with the architectural service specification of CAT. However, these standards and guidelines are not directly derived from any official BIM sources.
	Contractual	**Initial (a)** See Table 18 for Explanations	Although firm expresses high BIM maturity performance in some areas, there are still dependence of pre-BIM contractual arrangements. There is no indication related with BIM in the agreements.

Table 37. *Continuing*

	Preparatory	**Integrated (d)** See Table 19 for Explanations	Although there is no accepted official BIM standard in the firm, firm developed its own training requirements and BIM roles considering the market needs and architectural service specification of CAT. The firm hires consultants for training of staff for new updates and solutions in order to efficiently use.

Results and Discussion

Having two branches in Turkey could potentially propose network-based collaboration between two offices. However, the owner expressed that, BIM adoption stayed inside the branch offices. There was no need to advance BIM adoption between branch offices and there were not existing appropriate collaboration infrastructure between the offices in current conditions to enable collaborative BIM working in both offices at same time. The firm produced templates for project development according to building function, therefore; projects are developed according to their functions, and deliverables are produced considering these formats. The firm also constitutes an inner education format for their employees that every updates and upgrades are presented periodically to the staff in these education meetings. In case of necessity, the firm hires consultants for training the staff. Considering these circumstances, BIM maturity assessment results of the firm is presented in Figure 27 and 28.

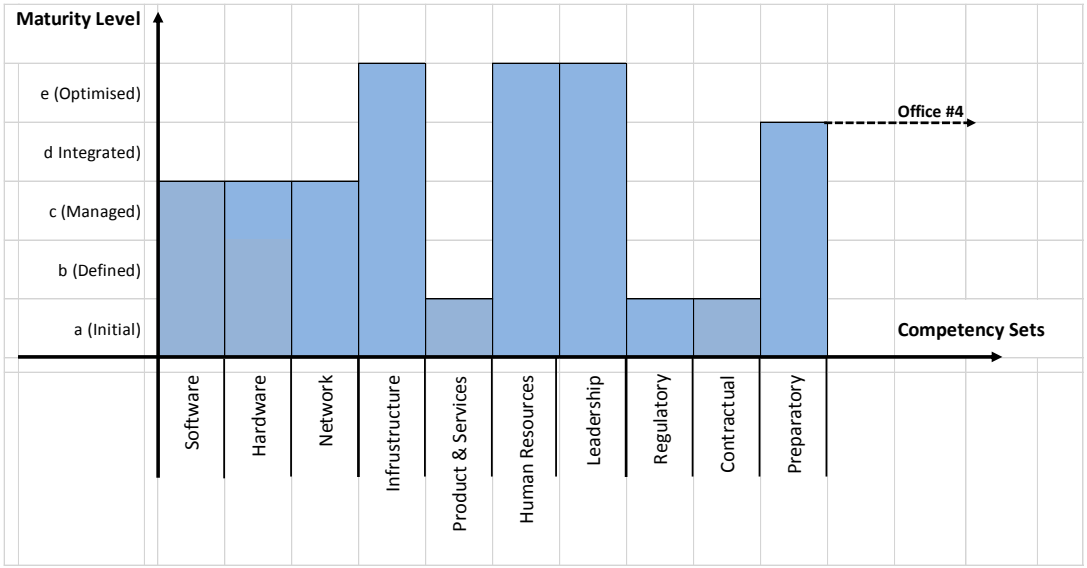


Figure 27. Diagrammatic expression of BIM maturity assessment result of Office #4

BIM Maturity Assessment for Office #4		a	b	c	d	e
		10 points	20 points	30 points	40 points	50 points
Technology	Software			●		
	Hardware			●		
	Network			●		
Process	Infrustructure					●
	Products & Services	●				
	Human Resources					●
	Leadership					●
Policy	Regulatory	●				
	Contractual	●				
	Preparatory			●		
Stage	Object-Base Modeling				●	
Scale	Organization (9)					●
Subtotal		30		120	40	200
Total Points						390
Maturity Score						**32.50**

Figure 28. BIM maturity score of Office #4

3.4.5 BIM Maturity Assessment of Office# 5

This firm has three branch offices. One of the office is located in Ankara and this office is the central office. The second office is located in Erbil, Northern Iraq. The third office is located in Milan, Italy. The BIM implementation is actively maintained in Ankara office.

Identification of Organizational Scale

The firm has three branch offices and only central office in Ankara work with BIM concept with seven staff. The assessment conducted to measure the BIM competency of the product and services provided by these staff. Therefore, considering the categorization illustrated in Figure 16, “organizational unit (10)” is accepted as organizational scale for this firm.

Detection of Capability Stages

Table 38. Capability Stages of Office #5

BIM Capability Stage		Maturity Level	Explanation of Maturity Level	Taken Notes
Stage-2	**Modelling-Based Collaboration**	**Defined (a)**	Single-thread, well-defined yet reactive BIM collaboration. There are identifiable signs of mutual trust and respect among project participants.	By the help of sustainable BIM implementation since 2013, the firm has achieved a level to illustrate industrial benefit of BIM to other project participants working together with this firm such as structural and electrical engineering. Structural and electrical engineering firms generate their own model and send to this firm. Therefore, there is single-thread data flow. However, these firms are not aware of the risks and other issues related with non-existence of BIM protocols. Furthermore, there is no conflict experienced yet among these firms. Therefore, it is possible to accept this situation as "defined" but not "managed"

Detection of Maturity Levels

Table 39. Technology Competency Sets of Office #5

		Maturity Level	Taken Notes
Technology	**Software**	**Optimized (e)** See Table 10 for Explanations	The firm does not delay investment on software upgrades. This idea is one of the objectives of the firm. New functions and solutions are followed and applied by a specific person charged with these assignments.
	Hardware	**Optimized (c)** See Table 11 for Explanations	Cost of hardware and software is not a matter for the firm if these are necessary for efficiency of the working processes. There is a specific person assigned to follow and apply new hardware and software upgrades and solutions. It is believed that investment on innovation increase the firm competitive advantages.
	Network	**Managed (c)** See Table 12 for Explanations	There is central server in each one of three offices. These servers are not connected to each other. Each user could harvest, store and share knowledge within organization and within office by established network on these servers. However, there is no connection and access provided to branch office in order to data share and storing between each other.

Table 40. Process Competency Sets of Office #5

		Maturity Level	Taken Notes
Process	**Infrastructure**	**Optimized (e)** See Table 13 for Explanations	Physical workplace is set for comfort and productivity of the staff. Every working practice is continuously reviewed and revised in weekly meetings.
	Products & Services	**Initial (a)** See Table 14 for Explanations	Although firm express high BIM maturity in some areas, there is no accepted and applied BIM standard for deliverables. Based on the current needs in usual practices, deliverables are prepared. Mostly, like other firms, services and deliverables are adjusted in compliance with project phases and deliverables described in architectural service specifications of CAT. For the projects developed to foreign countries, considering the needs of clients, services and deliverables are set but still without adapting any official BIM standard.
	Human Resource	**Optimized (e)** See Table 15 for Explanations	The BIM implementation is a part of the organization practice and not only aligned with organizational objectives but also become a competitive characteristic for the firm.
	Leadership	**Optimized (e)** See Table 16 for Explanations	The firm actively experiences this maturity level indications.

Table 41. Policy Competency Sets of Office #5

		Maturity Level	Taken Notes
Policy	**Regulatory**	**Initial (a)** See Table 17 for Explanations	There is a standard BIM training for new employees and there are also guidelines for BIM deliverables. BIM services are set considering the market needs, therefore; modeling and documentation standards are prepared in accordance with the architectural service specification of CAT.
	Contractual	**Initial (a)** See Table 18 for Explanations	Although firm expresses high BIM maturity performance in some areas, there is still dependence on pre-BIM contractual arrangements. There is still no indication related with BIM in the agreements. BIM is only a tool that accelerate the available services for the firm.
	Preparatory	**Optimized (d)** See Table 19 for Explanations	Although there are no accepted official BIM standard in the firm, firm developed its own training requirements and BIM roles considering the market needs and architectural service specification of CAT. The firm hires consultants for training of staff for new updates and solutions in order to efficiently use.

Results and Discussion

The BIM manager stated that the firm had started to implement BIM practices since 2013. As time has passed, firm's stability on BIM practices influenced other project participants such as structural and electrical engineering firms. Therefore, electrical and structural firms started to use BIM tools together with this firm and they were collaboratively developing projects using BIM concept. There are seven employees related with BIM applications in the office. Together with the owner of the firm, there is a specific person assigned to follow updates and upgrades related with BIM software and hardware upgrades. Updates are provided immediately without prevent the current practices inside the office. Furthermore, there are not only trainings related with upgrades and updates but also seminars are provided when needed. The level of BIM profession among staff is in almost same level. When a new employee starts to work in the office, according to the workload, other staff train the new employee until come up to same level with them. This vision establishes dynamic organizational model such as matrix structure in the office. The firm maintains this concept to have same efficiency from each staff. Considering the experiences of the BIM manager of this firm, BIM Maturity Matrix of the firm is presented in Figure 29 and 30. Although the firm has already started model-based collaboration with structural and electrical engineering firms, it still suffers from applications without the guidance of best practices. There is also lack of aware of BIM terminologies such as model ownership, BIM execution planning, *etc*. Although the firm has successfully implemented BIM, it seems that the achievement was mostly due to the organizational efficiency rather than best practice of BIM.

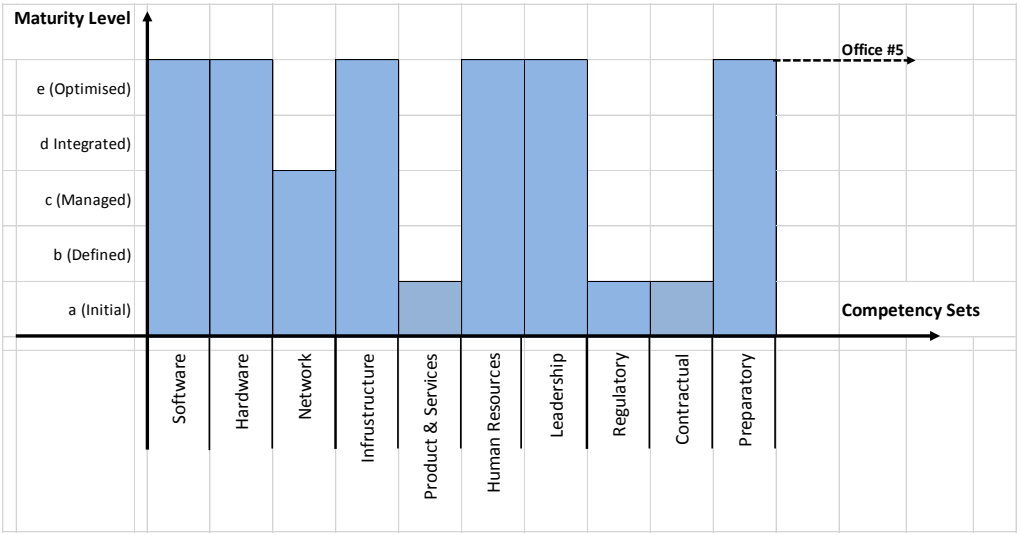


Figure 29. Diagrammatic expression of BIM maturity assessment result of Office #5

BIM Maturity Assessment for Office #5		a	b	c	d	e
		10 points	20 points	30 points	40 points	50 points
Technology	Software					●
	Hardware					●
	Network			●		
Process	Infrustructure					●
	Products & Services	●				
	Human Resources					●
	Leadership					●
Policy	Regulatory	●				
	Contractual	●				
	Preparatory					●
Stage	Modelling-Base Collaboration		●			
Scale	Organizational Unit (10)					●
Subtotal		30	20	30		350
Total Points						470
Maturity Score						**35.83**

Figure 30. BIM maturity score of Office #5

3.4.6 BIM Maturity Assessment of Office #6

This office is an engineering office located in Istanbul. The firm serves in structural and mechanical branches of engineering. The owner of the firm is at same time BIM manager of the firm. The BIM manager stated that he was a BIM educator before he decided to found his own engineering firm, and then he decided to found his own firm and started to give services in structural and mechanical branches in order to apply best practices of BIM. This enterprising make him the one of the first initiative that completely implements BIM concept in his organization. The firm has been utilizing BIM tools since 2011. The firm also encourages other disciplines on working on BIM platform since they started to implement BIM practices. Considering the statements of the owner of the firm, BIM Maturity Matrix assessment is presented.

Identification of Organizational Scale

Whole staff of the firm work with BIM concept. Therefore, considering the organizational category illustrated in Figure 16, “organization (9)” is accepted as organizational scale.

Detection of Capability Stages

Table 42. Capability Stage of Office #6

BIM Capability Stage		Maturity Level	Explanation of Maturity Level	Taken Notes
Stage-3	**Network - Based Integration**	**Defined (a)**	Integrated models are generated by a large subset of project stakeholders. Integration follows predefined process guides, standards and interchange protocols. Responsibilities are distributed and risks are mitigated through contractual means.	The firm utilizes CIC BIM protocols and standards, therefore; all of the procedure is in accordance with documented guides and standards as long as possible. BIM terminology are taken place in contracts because the firm demands payment from client considering the increased effort and efficiency provided with BIM to the project.

Detection of Maturity Levels

Table 43. Technology Competency Sets of Office #6

		Maturity Level	Taken Notes
Technology	**Software**	**Optimized (e)** See Table 10 for Explanations	The firm does not delay investment on software upgrades. This idea is one of the objectives of the firm. New functions and solutions are followed and applied in a regular cycle. Furthermore, training trips are also provided to staff related with learning updates and functionalities.
	Hardware	**Optimized (c)** See Table 11 for Explanations	Cost of hardware and software is not a matter for the firm if these are necessary for efficiency of the working process. BIM terminology take place in the contracts and based on services provided with BIM, the firm increase the value of the services.
	Network	**Integrated (d)** See Table 12 for Explanations	The firm has established necessary network infrastructure in the office to enable real time sharing of data, information and knowledge. Model-Based Integration is experienced.

Table 44. Process Competency Sets of Office #6

		Maturity Level	Taken Notes
Process	**Infrastructure**	**Optimized (e)** See Table 13 for Explanations	Physical workplace is set for comfort and productivity of the staff. Every working practice is continuously reviewed and revised in weekly meetings.
	Products & Services	**Optimized (e)** See Table 14 for Explanations	The firm adopted CIC BIM protocols. Current applications are regularly reviewed and new solutions are applied immediately.
	Human Resource	**Optimized (e)** See Table 15 for Explanations	Since its founding, the firm completely work in BIM concept and it is one of the avant-garde engineering firms in Turkey. One of the objectives of the firm establishment is demonstrating the best practices of BIM in engineering working field.
	Leadership	**Optimized (e)** See Table 16 for Explanations	The firm actively experiences these maturity level indications.

Table 45. Policy Competency Sets of Office #6

		Maturity Level	Taken Notes
Policy	**Regulatory**	**Optimized (e)** See Table 17 for Explanations	There is a standard training for new employees. Working practices are guided by best practice documents as much as possible. Working practice efficiency is one of the main title of regularly organized meetings.
	Contractual	**Defined (b)** See Table 18 for Explanations	Although the firm adopts CIC BIM protocols in their current practices, contractual maturity has just reached to defined maturity level. The main handicaps are unknown terms, unusual practices and way of procedure provided by BIM which are unusual for other project participants that strictly work in traditional methods.
	Preparatory	**Optimized (d)** See Table 19 for Explanations	The firm regularly arrange meetings in which, problems and handicaps confronted during the project execution are argued. Furthermore, continuous training is provided in these meetings. The owner of the firm takes benefit from his BIM educator experiences.

Results and Discussion

Due to non-existence of Turkish protocols and standards, the firm adopted and uses protocols and standards developed by Construction Industry Council (CIC). The firm could actively be a project participant of collaborative working practices and there are a couple of references experienced until now. The firm also installed network infrastructure to enable BIM model sharing by controlling and monitoring the office server access from outside of the firm such as architecture and construction firms. Not like the other five offices, this firm demonstrates higher maturity on areas of network, product and services, regulatory and contractual. This is due to the fact that, the firm adopt CIC BIM protocol and standards that encourages best practice of BIM. On the other hand, contractual maturity is still the lowest maturity area. The firm owner stated that, although they are utilizing CIC BIM protocol, it is hard to deal with other project participants that still practicing in traditional way. The new way of working practices and benefits coming with these practices are new and there is no clear sample to show benefits of BIM to other project participants in the market. However, after experiencing a couple of year with BIM in industry, other project participants saw the results of pilot projects. It takes time to reach "defined level" on contractual maturity area for the firm. Considering these statements, BIM maturity assessment of Office #6 is represented in Figure 31 and 32.

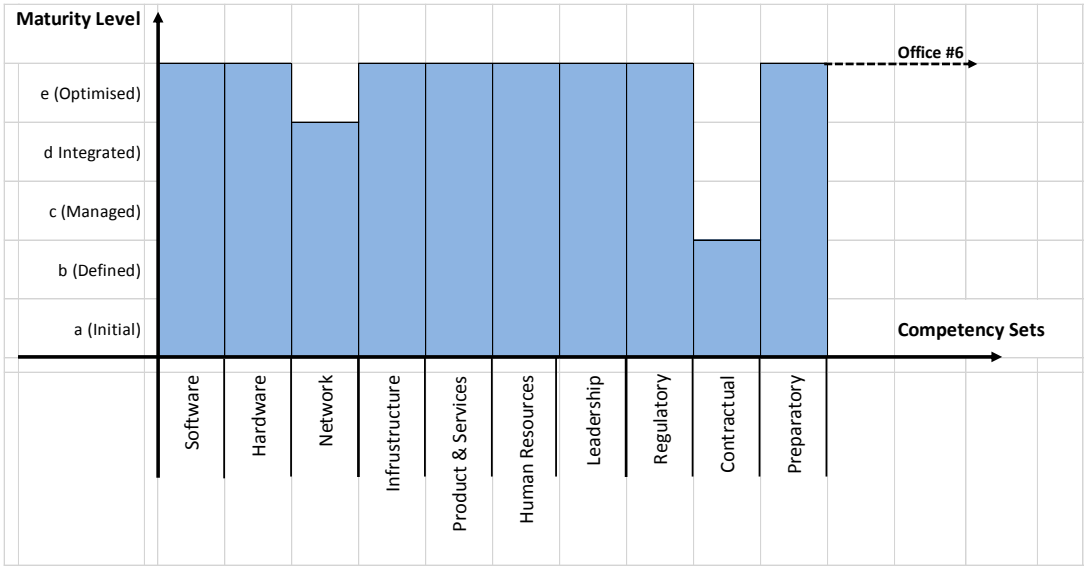


Figure 31. Diagrammatic expression of BIM maturity assessment result of Office #6

BIM Maturity Assessment for Office #6		a	b	c	d	e
		10 points	20 points	30 points	40 points	50 points
Technology	Software					●
	Hardware					●
	Network				●	
Process	Infrustructure					●
	Products & Services					●
	Human Resources					●
	Leadership					●
Policy	Regulatory					●
	Contractual		●			
	Preparatory					●
Stage	Modeling-Based Collaboration		●			
Scale	Organization (9)					●
Subtotal			40		40	450
Total Points						530
Maturity Score						**44.16**

Figure 32. BIM maturity score of Office #6

3.4.7 BIM Maturity Assessment of Office #7

The firm has approximately 180 employees that divided into four branch offices. The central office is located in Istanbul. Each office has its own BIM manager and BIM team. The firm's proficiency is based on architectural design. Central office has started to implement BIM practices since 3 years ago. Until the assessment time, the firm has achieved BIM transition on 20 employee in central office. The assessment was conducted with central office BIM manager. Considering those circumstances, BIM maturity assessment of this central office are presented in following subtopics.

Identification of Organizational Scale

The assessment includes 20 employees working with BIM concept among 180 staff of organization. These 20 persons established as BIM team, therefore; considering the explanations in Figure 16, "organizational unit (10)" is accepted as organizational scale.

Detection of Capability Stages

Table 46. Capability Stage of Office #7

BIM Capability Stage		Maturity Level	Explanation of Maturity Level	Taken Notes
Stage-2	**Modelling - Based Collaboration**	**Defined (a)**	Single-thread, well-defined yet reactive BIM collaboration. There are identifiable signs of mutual trust and respect among project participants.	Generated digital data prepared by other design teams flow to the central office therefore, single-thread and well-defined BIM collaboration are existing. Having experience of long-term practice in the market, there are identifiable signs of mutual trust and respect among project participants.

Detection of Maturity Levels

Table 47. Technology Competency Sets of Office #7

		Maturity Level	Taken Notes
Technology	**Software**	**Optimized (e)** See Table 10 for Explanations	There is a crew to follow updates and upgrades inside the organization. The firm does not delay investment on software upgrades. This idea is one of the objectives of the firm. New functions and solutions are followed and applied in a regular cycle. Furthermore, training trips are also provided to staff related to learning updates and functionalities.
	Hardware	**Optimized (e)** See Table 11 for Explanations	There is a crew to check and apply updates and upgrades inside the organization. Continuous testing and upgrading is also monitored by this crew. BIM hardware and software is a tool to increase the quality of services and products.
	Network	**Managed (c)** See Table 12 for Explanations	Each branch office has its own server but they only serve to inside the branch office. Generated digital data and knowledge stored in these servers but shared via cloud base web sites. Other project participants could only download, share and upload digital data through these cloud base websites. Network infrastructure is adequate to enable model-based collaboration with other project participants.

Table 48. Process Competency Sets of Office #7

		Maturity Level	Taken Notes
Process	**Infrastructure**	**Optimized (e)** See Table 13 for Explanations	Physical workplace is set for comfort and productivity of the staff. Every working practice is continuously reviewed and revised in weekly meetings.
	Products & Services	**Integrated (d)** See Table 14 for Explanations	The firm serves in international market. Depending on the client requirements, the firm could adopt both CIC and AIA BIM protocols. Considering the explanations of BIM manager, the working structure is more stable and integrated rather than as intended to be dynamic and continuous in optimized level due to the variety of product and services in the market.
	Human Resource	**Optimized (e)** See Table 15 for Explanations	The BIM competency targets are continuously reviewed and aligned with organizational objectives. Productivity is consistent and evaluated regularly.

Table 48. *Continuing*

	Leadership	**Optimized (e)** See Table 16 for Explanations	Although whole staff of the firm has not yet adopted BIM due to the cost and time of BIM implementation of whole staff is not affordable, the administrative units give all their support as much as possible on BIM implementation. Every implementation step and stage is closely controlled, monitored and reviewed in regular meetings

Table 49. Policy Competency Sets of Office #7

		Maturity Level	**Taken Notes**
Policy	**Regulatory**	**Integrated (e)** See Table 17 for Explanations	There is a standard training for new employee. Working practices are guided by best practice documents as much as possible. Working practices efficiency is one of the main title of regularly organized meetings.
	Contractual	**Managed (c)** See Table 18 for Explanations	Having many years of experience on international market, the firm established its own mechanism to resolve BIM conflicts.
	Preparatory	**Integrated (d)** See Table 19 for Explanations	As being part of organizational strategies, the firm gives a standard BIM training to the staff to gain medium level proficiency, then according to the role and responsibility in the project team, the experienced personnel trains the staff to bring the employees to the intended proficiency level. Instead of being dynamic and regularly upgraded like in optimized level, this system is stable and consistent like in integrated maturity level.

Results and Discussion

Although having four branch offices at different locations and countries, the firm has not initiated instant collaborative working in between branch offices. BIM manager stated that they do not need to work collaboratively among branch offices. She also mentioned that, they tried collaborative work at start of BIM implementation, on the other hand; they found out that the network infrastructure of Turkey was inadequate to enable instant collaborative working between different offices upon network connection. Instead of instant collaborative working, the firm

choses model-based collaboration, in other words; sub-models are generated by different design team and then collected together. Having many years of experience on international market, the firm established its own system to solve conflicts arising from BIM. Nevertheless, this system is not completely integrated with organization working practices. Thus, contractual maturity area is demonstrated in managed level. Regarding these circumstances, BIM maturity assessment of Office #7 is illustrated in Figure 33 and 34.

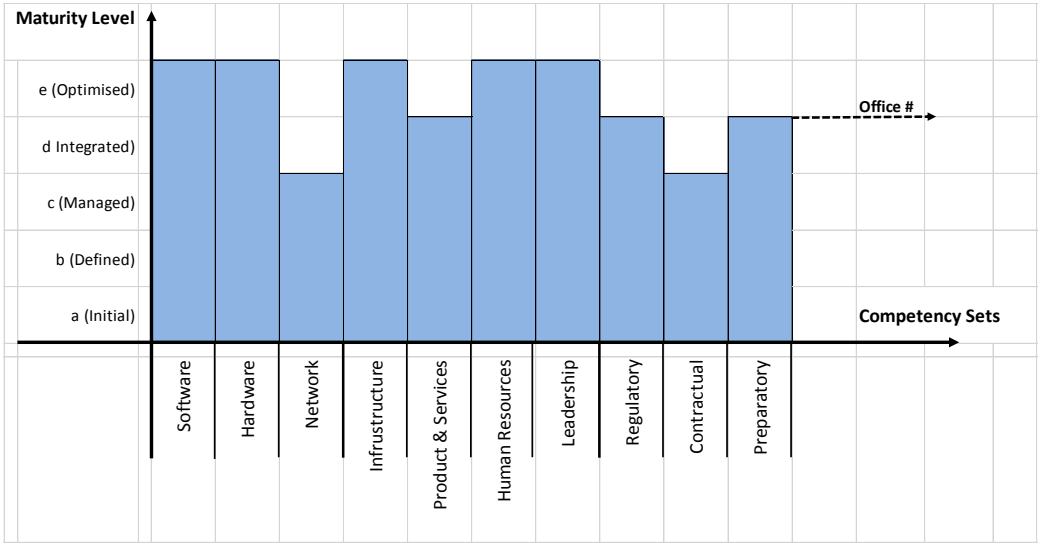


Figure 33. Diagrammatic expression of BIM maturity assessment result of Office #7

BIM Maturity Assessment for Office #7		a	b	c	d	e
		10 points	20 points	30 points	40 points	50 points
Technology	Software					●
	Hardware					●
	Network			●		
Process	Infrustructure					●
	Products & Services				●	
	Human Resources					●
	Leadership					●
Policy	Regulatory				●	
	Contractual			●		
	Preparatory					●
Stage	Modeling-Based Collaboration		●			
Scale	Organizational Unit (10)					●
Subtotal			20	60	80	350
Total Points						510
Maturity Score						**42.50**

Figure 34. BIM maturity score of Office #7

Table 50. Analysis of weak BIM maturity areas. The subtitles of BIM maturity areas are derived from: (Succar, 2010)

BIM Maturity Areas		Relation of Benchmark Item with Firms
Network	**Network Solution**	Technical issue and firm specific
	Deliverables	Technical capability of the firm to deliver products and services
	Security and Access Control	Technical issue and firm specific
Product & Services	**Service Specification**	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Product Specification	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Product and Service Differentiation	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Project Delivery Approach	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Research and Development	Should be described and released by official authorities and the firm needed to apply it in its working practices
Regulatory	**Rules and Directives**	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Standards and Classifications	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Guidelines and Benchmarks	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Codes and Regulations	Should be described and released by official authorities and the firm needed to apply it in its working practices
Contractual	**Responsibilities**	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Rewards	Should be described and released by official authorities and the firm needed to apply it in its working practices
	Risks	Should be described and released by official authorities and the firm needed to apply it in its working practices

CHAPTER 4

4 UNDERSTANDING THE PRACTICAL BARRIERS OF BIM IMPLEMENTATION IN TURKEY

4.1 Introduction

The objective of BIM maturity assessment is drawing the frame of BIM implementation among Turkish SME design firms and unveiling the practical barriers. After conducting and taking valid results of BIM maturity assessment, in this section, the focus is given to practical handicaps. The following parts of this section is established upon derived results of BIM maturity assessment that studied in Chapter 3.

The common weak BIM maturity areas were resulted as network, product and services, regulatory and contractual. Considering the content as analyzed in Table 50, network is a technical issue. Establishing a section examining background factors of network maturity area was thought that it will move the study out of the objectives. Therefore, instead of examining network, other three weak maturity areas were focused on and further studied. On the other hand, due to content and benchmarking similarity illustrated in Table 50, product and services, regulatory and contractual maturity areas are based on official documents such as standards, specifications, guides and protocols, which are developed by official authorities. Therefore, after completing BIM maturity assessment study, the main focus in the following chapters are given to understanding the handicaps of BIM

implementation caused by lack of official documents rather than examining technical problems.

After gaining popularity of BIM implementation, the official authorities giving services to AEC industry started to release guiding documents to provide guidance to efficiently implement BIM (AEC UK Initiative, 2012; AIA, 2013; CICRP, 2010; CURT, 2010; IU, 2009; UCL, 2015). Furthermore, there are studies that consider the amount of released official BIM documents as a criteria for BIM maturity of countries (Kassem et al., 2013).

During the BIM maturity assessment research, it was observed that only two firms adopted and applied official BIM documents in their BIM implementation. These are Office #6 and #7. While Office #6 implemented Construction Industry Council (CIC) BIM documents in their practices, Office #7 implement both CIC and American Institute of Architects (AIA) BIM documents in their practices based on market and client requirements.

It was also a question for this study whether there are any existing official BIM documents released in Turkey. After completing BIM maturity assessment, whether the existence of BIM protocols, standards and guides that released by Turkish authorities were searched. For this goal, an e-mail that asking the list of publications and studies released for BIM and related with BIM was sent in 2016 to the Ministry of Environment and City, Ministry of Development, Turkish Standard Institution and Chamber of Architects of Turkey, which are officially giving services to AEC industry practices. Considering the reply coming from these official authorities , there are no studies prepared in BIM field. Therefore, current architectural practices are based on the existent guides, standards, codes and laws, which are not prepared to provide guidance to BIM implementation. The list of these guides, standards and laws are presented in Table 51.

Table 51. List of the documents to provide guidance to architectural services in Turkey

Document	**Reference**
Chamber of Architects of Turkey, Architectural Service Specifications and Least Cost Schedule	Chamber of Architects of Turkey (CAT) (TMMOB, 2006)
Chamber of Architects, Standards of Architectural Drawing and Presentation	Chamber of Architects of Turkey, Istanbul Brand (TMMOB, 2012)
Basics of Architectural Project Editing	Ministry of Public Works and Residence (BIB, 1979)

In order to unveil how current available official documents causes handicaps in BIM implementation, a comparison study is prepared to deeply see the differences of best practices of BIM and available practices in Turkey on product and services, regulatory and contractual BIM maturity areas. For this goal, official BIM documents of AIA and CIC, which are released in United States and United Kingdom respectfully, is compared with official architectural service documents of Chamber of Architects of Turkey (CAT), which is the current architectural services and contracts are based on (TMMOB, 2006). The comparison criteria are derived from best practice guides released in United States and United Kingdom.

After conducting the comparison table, evaluation and discussion session followed the process. In order to validate the findings, a survey was sent asking the applications and comments on the "key BIM terms" to the design firms that participated the initial BIM maturity assessment study.

4.2 Collection of Key BIM Terms

In order to establish the comparison in an objective platform, comparison criteria are derived from best practice guides of two different countries. This situation provides not only understanding the barriers to BIM implementation in Turkey, but also unveiling the differences of BIM approach of these two countries. Three BIM implementation and best practice guides were reviewed to find out which terms and applications should take place in a BIM protocol or contract. By comparing, evaluating and synthesizing the available terms and applications taken place in these guides related sections, the resulted list shown in Table 52 has been prepared and used in the study.

Table 52. Key BIM Terms shall be mentioned in a BIM Protocol

Key BIM Terms	**References**
Model Development and Responsibilities of Parties Involved	(AEC UK Initiative, 2012; CICRP, 2010)
Model Sharing and Model Reliability	(CICRP, 2010)
Interoperability / File Format	(CICRP, 2010)
Model Management	(CICRP, 2010)
Intellectual Property Rights	(AEC UK Initiative, 2012; CICRP, 2010)
Requirement for BIM Execution Planning	(AEC UK Initiative, 2012; CICRP, 2010; CURT, 2010)
BIM Project Reviews	(AEC UK Initiative, 2012)
Model Element Authorship	(AEC UK Initiative, 2012)

4.3 Comparison of AIA and CIC BIM Protocols with Chamber of Architects of Turkey (CAT) - Architectural Service Specification

In this section, a comparison between the BIM documents of AIA and CIC, and Architectural Service Specification of Chamber of Architects of Turkey (CAT) were conducted by representing each key BIM terms in a sub-topic.

4.3.1 Documents Reviewed

AIA	- AIA Document E203-2013 Building Information Modeling and Digital Data Exhibit (AIA, 2013) - G201-2013 Digital Data Protocols (AIA, 2013) - G202-2013 Building Information Modeling Protocols (AIA, 2013) - NBIMS-US National BIM Standards Version 3 (NBIMS-US, 2015)
CIC	- CIC BIM Protocol, First Edition (2013), Appendix-1; Production and Delivery Table (MPDT), Appendix-2; Information Requirements – (IR) (CIC, 2013) - Employer Information Requirements (EIR) (BIMTG, 2013) - PAS 1192-2:2013 (BSI, 2012)
CAT	- Chamber of Architects of Turkey (CAT) Architectural Service Specifications and Least Cost Calculation (TMMOB, 2006)

4.3.2 Parties Mentioned in the Documents

AIA	Two type of person or entity were defined; party for signing parties to the agreement and project participant for entity or individual providing services, work, equipment or materials to the project. The term "project participant" also includes the parties. The intention in here is to increase the impact of the agreement go beyond the just two party. In other words, the aim is providing an appropriate agreement medium to increase the project participant's integration. On the other hand, in both Digital Data Protocol and Building Information Modeling Protocol, the role of architect is emphasized because architect has the opportunity to take place in the early stage of the project until its completion
CIC	Employer and Project Team Member is the main parties in the standard form of CIC BIM Protocol
CAT	Employer/Owner and Architect are the main parties in the specification

4.3.3 Model Development and Responsibilities of Parties Involved (AEC UK Initiative, 2012; CICRP, 2010)

AIA	AIA Document E203-2013 Building Information Modeling and Digital Data Exhibit anticipate the model development and responsibilities of parties. Furthermore, G202-2013 Building Information Modeling Protocol is giving opportunity to parties to establish further detailed descriptions of model development and responsibilities of parties
CIC	Appendix 1 and Appendix 2 of CIC BIM Protocol (2013) clearly describe the procedure of model development and role and responsibilities of parties by providing "Model Production and Delivery Table (MPDT)" and "The Information Requirements (IR)" respectively. Furthermore, Clause 4 obligates the parties to comply their working procedure with MPDT and IR (CIC, 2013).
CAT	There is no statement related with model development in the specification. However, in section 4, Item 16 and 17 clearly describe the duty, liability and rights of the both architect and employer/owner during the project phases. Furthermore, in Section 2, Item 7-1 to 7-16 provide a comprehensive description of the project phases.

4.3.4 Model Sharing and Model Reliability (CICRP, 2010)

AIA	AIA Document E203-2013, Section 4.5 - model protocols leads the parties to prepare and establish G202-2013 Building Information Modeling Protocols. In accordance with the agreed upon G202-2013 Building Information Modeling Protocol, Section 4.6 of E203-2013 provides parties to develop, use, and rely on the model. Section 4.7.2 of E203-2013 states that in case of inconsistent authorized uses of model identified in the modeling protocols, all of the risk shall be owned by the party using or relying on the model.
CIC	The CIC BIM Protocol in standard form does not give any liability to the project team member in terms of integrity of any electronic data delivered to the other parties. Furthermore, project team member, as having the intellectual property rights of the model has no liability to rely on the model after it is transmitted by project team member to the other parties.

CAT	There is no statement related with model sharing and reliability, However, Section 4, Item 16-2 - duty and responsibility of architect to the employer/owner states that architectural services provided by architect to Employer/Owner required to be accurate and complete (TMMOB, 2006). Thus, it is possible to say that the drawings and data depicted in the drawings submitted by architect to the employer/owner required to be reliable. On the other hand, in case of conflict arising due to lack of collaboration during the project execution between other project participants that assigned by employer/owner with permission of architect, architect has a kind of responsibility, however; architect is not responsible from the failures arising from those related with project participant's field of profession (TMMOB, 2006).

4.3.5 Interoperability/File Format (CICRP, 2010)

AIA	File formats and digital data transmission method take place in G201-2013 Section 3.1 that parties and project participants have to clearly describe the file format and interoperability options.
CIC	File format and the versions of the necessary software take place in detail in Appendix 2 - Information Requirements Clause 3 - Employer's Information Requirements, Item 3.2 and 3.3.
CAT	There is no description related with interoperability/file format in the specification.

4.3.6 Model Management (AEC UK Initiative, 2012; CICRP, 2010)

AIA	AIA Document E203-2013, Section 4.8 sets the roles, responsibilities and protocols of model management. This section also includes the following titles; assignment of model manager (Section 4.8.1), model management protocol establishment (Section 4.8.2), responsibilities of model manager (Section 4.8.3) and model achieving procedures (Section 4.8.4)

CIC	CIC BIM Protocol Clause 4 requires the employer to appoint an information manager from another party to take over the "Information Management Role". Information Manager is the responsible person for management of model, process and procedures throughout the project phases.
CAT	There is no definition related with model management. On the other hand, it is the architect's duty to manage and control the project execution and development comply with the architectural project through the other project participants.

4.3.7 Intellectual Property Rights (AEC UK Initiative, 2012; CICRP, 2010)

AIA	AIA Document E203-2013 proposes two definition to meet the intellectual property rights: Section 1.4.5 Authorized Uses and Section 1.4.6 Model Element Author. Section 1.4.5 Authorized Uses refers to the allowed uses of digital data. Section 4.3 provides the anticipation of model authorized uses which will be further detailed in G202-2013. Section 1.4.6 Model Element Author is the entity or individual responsible for managing and coordinating the development of a specific Model Element, regardless of who is responsible for providing the content in the Model Element. Model Element Author is further be identified in Section 3.3 of G202-2013 - Model Element Table. E203-2013 Section 2.3 gives rights to each party to transmit digital data to receiving party to use, modify or further transmits Digital Data in the limitation of the definitions and protocols provided by E203-2013, G201-2013 and G202-2013. Thus, it is possible to say that, AIA Document E203-2013 gives partial intellectual property rights to the project participants, in a certain project phase in agreed upon with other project participants.
CIC	The standard form of CIC BIM Protocol, Clause 6 sets out the Intellectual Property Rights. Clause 6.2 gives the copyright of the project to the "Project Team Member". If the Employer wants to own the Intellectual Property Rights of the project then the protocol should be revised. Clause 6.3 provides a license to the Employer to use the material (the electronic information contained in the model produced by the Project Team Member) for the Permitted Purpose. Clause 6.6 and 6.7 provide license and sub-license from the Employer to the Project Team Member for the information contained in the model provided by Employer for the Permitted Purpose. Permitted Purpose in here means the licensed uses of Models. Therefore, parties in this protocol provide licensed uses of Models for the information provided by vice versa. On the other hand, Intellectual Property Rights of the project is owned by Project Team Member.

CAT	Architect is the author of the project and authorship of a project could not be transferred to the other project participants even in the case of architect wishes to do (TMMOB, 2006).

4.3.8 Requirement for BIM Project Execution Planning (AEC UK Initiative, 2012; CICRP, 2010; CURT, 2010)

AIA	BIM Roles and responsibilities, data management and project milestone are taken place and anticipated in E203-2013 and then further detailed in G201-2013 and G202-2013 documents. Although these items are elements of BIM execution planning, there is no direct reference to prepare a BIM Execution Plan in the protocol.
CIC	The BIM Execution Planning is not directly mentioned in the protocol. However, preparation and implementation of BIM Execution Plan in accordance with PAS 1192-2 by information manager is advised in Employer Information Requirements (EIR) document (BIMTG, 2013). Moreover, preparation of BIM Execution Plan is required in PAS 1192-2 (BSI, 2012) and the parties who signed the protocol are required to comply with PAS 1192-2. Therefore, it is possible to state that preparation and implementation of BIM Project Execution Planning is obligated.
CAT	There is no description or statement related with BIM Execution Planning in the specification

4.3.9 BIM Project Reviews (AEC UK Initiative, 2012)

AIA	Both Digital Data and Building Information Modeling Protocols are directly encouraged to review and revise the protocols in case of necessity at appropriate intervals in E203-2013 document. Furthermore, project reviews in each project development phase is regularly stated in National BIM Standards, version 3 (NBIMS-US, 2015).
CIC	The BIM Project Reviews are not directly mentioned in CIC BIM Protocol and none of the other documents related with CIC BIM Protocols.

CAT	There is no description and statement related with BIM Project Reviews. In fact, architect described as a project author and after submission of the project to the Employer/Owner, architect relation with other project participants is described as: managing and controlling the project execution in order to provide that project is executed compiling with the architectural drawings. Thus, collaboration, communication and integration of project participants are not advised. Instead, conflict of interest among project participants is established and under these circumstances, the rights of architects are preserved.

4.3.10 Model Element Authorship (AEC UK Initiative, 2012)

AIA	AIA Document E203-2013, Section 1.4.6 mention the model element author and draw the frame of the authorship by directing the parties to establish the Model Element Table in Section 3.3 of G202-2013.
CIC	Project Team Members own all of the copyrights of the model, and Project Team Member shall provide a license and sub-license to the Employer to copy, modify and transmit the model and data in the model to be used by taking written permission from the Project Team Member in terms of "Permitted Purpose". Thus, in the standard form of CIC BIM Protocol, model element authorship is provided to the project team members and project team members provide license to the employer to transmit the digital data to the other project participants.
CAT	There is no definition and description related with Model Element Authorship, however; authorship of project is given to the architect and it could not be transferred to other project participants, even in the case of architect wishes to do so.

4.4 Evaluation and Analysis of AIA and CIC BIM Protocols with CAT Architectural Service Specification

As it was stated in the objectives, understanding the current working environments of design firms during the BIM implementation is the focus of this study. Thus, in evaluation phase of this study, a discussion of current working practices of Turkish

design firms regarding the information given in the comparison study stated in Section 4.3 of this chapter is conducted. Considering the key BIM terms stated in comparison study, evaluation of current working practices regarding the AIA and CIC BIM protocols are argued according to two scenario.

The origin of these scenario come from the BIM implementation practices of the firms that participated the BIM maturity assessment study. The taken notes during the assessment resulted that the firms could be divided into two category as implementing any of official BIM documents during BIM adoption or not. As it was represented in the taken note sections of BIM maturity assessment application, Office #1, #2, #3, #4, and #5 is not applying any of official BIM document while Office #6 and #7 applying either AIA or CIC BIM documents during their practices. Therefore, this situation reviewed as two BIM implementation scenario in this study.

In first scenario, the architecture firm implement BIM practices by adopting the implementation procedure in comply with the existing CAT Architectural Service Specification. In second scenario, architecture firm adopt another country BIM protocol such as AIA and CIC. In this situation, the firm is confronting with a working environment that all of the procedures related with project development is proceeded with the CAT Architectural Service Specifications. In terms of these conditions, second scenario was argued.

4.4.1 Documents Reviewed

As it was mentioned in initial section of this study, Both AIA E203-2013 Building Information Modeling and Digital Data Exhibit, and CIC BIM Protocol is released to provide guidance for practical needs of AEC industry after implementation of

BIM. However, this objective has not mentioned yet in CAT – Architectural Service Specification. Furthermore, both America and UK generated their own BIM standards in order to support the BIM practice. Turkey has not had a BIM standard to apply in the AEC industry. Therefore, the firms that initiating BIM implementation program could not apply a BIM standard, which is generated for Turkey. This means that, the firms are either developing their own standards and service methods which is possible to be similar with the CAT – Architectural Service Specification or the firms are adopting another country BIM Standards in which this situation was observed in Office #6 and Office #7 during the BIM maturity assessment study.

4.4.2 Parties Mentioned in the Documents

The approach of CAT - Architectural Service Specification is similar with the CIC BIM Protocol in terms of approach of parties and protection and definition of party's roles, responsibilities and rights. AIA BIM Protocol defines the role, responsibility and actions of the project participants in a more integrated and collaborated way than CIC BIM Protocol and CAT - Architectural Service Specification. Both CIC BIM Protocol and CAT – Architectural Service Specification describe the rights of project team members and architect in detail and focus on the responsibility and preservation of rights of Project Team Member and Architect as a party in the protocol and specification respectfully.

4.4.3 Model Development and Responsibilities of Parties Involved (AEC UK Initiative, 2012; CICRP, 2010)

In the CAT – Architectural Service Specifications in Section 4, Item 16 and 17 clearly describe the duty, liability and rights of the both architect and employer/owner during the project phases. Section 2 of the document, Item 7-1 to 7-16 provide a comprehensive description of the project phases. Considering these circumstances, if a firm chooses to proceed in first scenario, model development may proceed in comply with the project phases described in CAT - Architectural Services Specification. Responsibilities of parties will needed to compile with the Item 16 and 17 of the specification also. In that case, due to non-existence of model development description in the specification, it is possible to confront with a situation that architectural firms will increase their effort on project development and take more responsibility on model development.

For second scenario, the firm is needed to introduce another country's BIM protocol to the other project participants. In that case, new model development procedure and responsibilities of parties should be agreed upon among the project participants. It is important to notice that current practices are based on the CAT - Architectural Service Specification and it could take time for the project participants to get used to the new terms. Furthermore, due to not getting involved in the CAT - Architectural Service Specification of those new introduced terms, in case of conflicts arising from the model development and responsibilities of parties, the firms are possible to confront with chaotic cases.

4.4.4 Model Sharing and Model Reliability (CICRP, 2010)

As it was argued in comparison study depicted in Section 4.3.4, there is no direct reference to model sharing and model reliability in CAT - Architectural Service Specification. However, this specification requires architect to submit correct drawing and data to the employer/owner. Therefore, considering this requirement, for the first scenario, it is possible to state that, the firms in Turkey who are

implementing the items of CAT - Architectural Service Specification will feel to have a responsibility on model reliability. Architecture firms will have an instinct to provide accurate data in the model. On the other hand, there is no reference and method depicted related with model sharing in the specification. The specification requires hard copy submission of the drawings in general, thus it is possible to say that model sharing could be continue as sharing the 2-D drawings of the model to the related discipline, as this procedure is depicted as hardcopy submission of 2-D drawings. Therefore, model sharing will not take so much attention in Turkish practice. This situation also suffers from low network infrastructure of Turkey which of this situation was demonstrated in BIM Maturity Matrix results. Network is the third least maturity level in the matrix.

For the second scenario, the firm will provide warranty to reliability of the model and provide model sharing options. Model reliability as it was argued in first scenario is familiar issue for the firms; on the other hand, model sharing option requires adequate network infrastructure and existence of agreed upon digital data protocol. As it was mentioned in BIM maturity assessment of the firms, network infrastructure is in low maturity level in Turkey. There are new terms related with digital data protocols and the project participants should know and agree upon these terms in order to proceed. However, considering these circumstances, it is possible to be successful on providing model reliability, on the other hand; for model sharing, it seems to confront with inefficient network conditions.

4.4.5 Interoperability/File Format (CICRP, 2010)

The submissions of architect to owner/employer is stated as hard copy of the drawings, thus, there is no statement existent in the CAT - Architectural Service Specification related with interoperability/file format.

Considering the above statement, in case of first scenario, when a firm implements BIM practices according to CAT - Architectural Service Specification, it is possible to proceed the data and drawing transfer on 2-D drawings. Therefore, the file format would be an appropriate file format which will enable 2-D drawing transfer such as dwg, dxf or pdf.

According to second scenario, the firm will prepare a BIM execution plan and describe the file format in the agreement. However, due to usual practice of CAT - Architectural Service Specification, other project participants will not be aware of interoperability/file format and get used to the working practices based on 2-D drawing transmission. Therefore, it is possible to confront with whatever BIM maturity is provided, due to the non-existence of BIM experience among other project participants, interoperability/file format option would stay in 2-D drawing transmission.

4.4.6 Model Management (AEC UK Initiative, 2012; CICRP, 2010)

According to the CAT - Architectural Service Specification, architect's duty is limited to control and manage the project development from design phase to construction phase in accordance with the original design. The data transfer in this condition was conducted by 2-D drawing transfer among project participants. Thus, architect in each control phase of other discipline stayed in the idea of whether the other disciplines developed the project under the original limit and boundary of the project which is generated by architect. In this situation, instead of project management, it is possible to define this procedure as project documentation checking. Considering this argument, in first scenario, due to non-existence of interoperability/file format, model sharing and other collaborative processes during the project execution, there would be no existence of any model management among project participants. In second scenario, due to the lack of options stated in first scenario among project participants, it is possible to suffer from same result

that there would be no collaborative environment and this situation will lead non-existence of any model management.

4.4.7 Intellectual Property Rights (AEC UK Initiative, 2012; CICRP, 2010)

According to the CAT - Architectural Service Specification, after completion of pre-project works (Item 7-2) architect deserved to own the authorship of the project. After this phase, architect has the authorship of the project which could not be delivered to any one even in case of architect wishes to do. Considering this situation, in first scenario, due to the familiarity of the terms provided in CAT - Architectural Service Specification, it is possible to state that architect would like to own all of the rights related with project model generated by architect. Due to conflict of interest and separated work of disciplines in current Turkish working practice, every project participant who provide model to central model would like to own the authorship of the model. However, as the similar description stated in CIC BIM Protocol, general model authorship and intellectual property rights will be owned by architect; on the contrary, architect will be responsible for all of the drawing and data derived from the model which of this situation is not similar in CIC BIM Protocol. This is due to the fact that, in CAT - Architectural Service Specification, Section 4, Item 16-2, it is the architect's duty and responsibility to provide accurate and correct drawing and information in the drawing to the employer. Considering above arguments, in first scenario, architect will behave as it was interpreted in above section. In second scenario, if the firm chooses AIA BIM Protocol, it is possible to confront with a conflict on model element authorship and authorized uses because there is no direct statement related with these two terms in CAT - Architectural Service Specification. Thus, other project participants may not welcome these new terms and approaches of AIA. This conflict is also valid if the firm chooses to adopt CIC BIM protocol because although CIC BIM protocol provides intellectual property rights of the model to the project team member,

which could be, almost similar in CAT - Architectural Service Specification, there is no definition related with licensed use or permitted purpose.

4.4.8 Requirement for BIM Project Execution Planning (AEC UK Initiative, 2012; CICRP, 2010; CURT, 2010)

There is no reference to BIM Execution Planning in CAT - Architectural Service Specification. Second section of this document lists the architectural services and defines the project development phases. It is clear to state that second section is not requiring any kind of collaborative working such as BIM Execution Planning that is preparation of it requires early collaboration of project participants in pre-design phases. Instead of this approach, CAT - Architectural Service Specification supports the diverse and fragmented work of each discipline and, architect is responsible for the management and control of the project development from design phase to bidding phase. Project Execution Planning drawes a comprehensive and multi-participant working environment. On the other hand, CAT - Architectural Service Specification Document describes and orders the role, duty, responsibility, rights and working phases of architect and Employer/owner. Thus, collaboration environment is limited to two parties; architect and employer/owner, in other words; there is no need to mention or reference to project execution planning. In terms of these statements, for the first scenario, due to even no reference to any project execution planning, the firm may choose to try to adopt the project development phases described in second section of CAT - Architectural Service Specification, Item 7-1 to 7-17. In that case, it is possible for the firm to confront with inadequate BIM working environment due to inefficient role and responsibility definition in between project participants. For the second scenario, it is possible to work with efficiently if the firm either chooses to work with AIA BIM protocol or CIC BIM protocol. Increased need for communication, collaboration and interoperability among project participants in Turkish AEC industry, which was mentioned in 10th

Development Plan in 2013 (TCKB, 2013) will make it easy to implement BIM project execution planning.

4.4.9 BIM Project Reviews (AEC UK Initiative, 2012)

BIM project reviews means sequential meeting of project participants in order to review, revise and develop the BIM project. As it was mentioned in the comparison study, there is no reference to BIM Project Reviews in CAT - Architectural Service Specification. Instead of this approach, conflict of interest among project participants were established and at the end of each project development phase stated in Item 7, Section 2 of the specification, architect submits the 2-D drawing and document of each phase to the employer/owner. During the execution of project phases established in the document, architect's and employer's/owner's duty, responsibility and rights are defined and it was expected from all of the parties to comply with these project phases. Under these circumstances, for first scenario, due to lack of definition in the Specification Document, it may be hard for the firms to establish BIM project reviews because otherwise, there is no official enforcement to do. However, as it was stated in above section, there is existing a need for increased communication, collaboration and interoperability in order to increase the working quality among project participants that may remove the need for formal enforcement to BIM project reviews. For second scenario, both of the BIM protocol advise the BIM project reviews, so considering the need for project review procedure among project participants in Turkish AEC industry practitioners, it may be easy to establish BIM project review meetings.

4.4.10 Model Element Authorship (AEC UK Initiative, 2012)

Project authorship is defined in CAT - Architectural Service Specification, and it is protected with law that project authorship could not be transferred to any other party even in the case of architect wishes to do. The definition of project authorship is holistic and model element authorship is an issue that cover a small group of model rather than whole model. Considering the CAT - Architectural Service Specification conservative items generated for preserving the rights of architect, model element authorship has potentials to cause conflicts in the AEC industry of Turkey. AEC industry participants get used to be owned the project authorship by architect thus, considering the first scenario, it is possible to argue that architect will want to own model element authorship. However, due to the conflict of interest, architect will not want to own the responsibility of rely on the information provided with model element. Considering the second scenario, as it was mentioned in the comparison study, both of the BIM protocol provide different role and responsibility on model element authorship. The CIC BIM protocol approach to copyright and permitted purpose seems similar with CAT approach in terms of preserving the rights of architect. Thus, it is possible to state that CIC BIM protocol could be implemented more successfully than AIA BIM protocol. Moreover, AIA BIM Protocol approach on model element authorship is flexible that, it is in conflict with the terms stated in CAT - Architectural Service Specification. Furthermore, in a practical environment that CAT is required to define and preserve the copyrights of the architect may cause abuse of the rights of the model element authors when this right is open to be owned by other project participants.

CHAPTER 5

5 DISCUSSION OF BARRIERS FOR BIM PRACTICE IN TURKEY AMONG SME DESGIN FIRMS

In initial section of this study, handicaps of the firms for who implemented BIM practices were argued considering the two scenario; in first scenario, the firm implement BIM practices and try to comply with current specifications that the sector goes on. In second scenario, the firm chooses to adopt either AIA BIM protocol or CIC BIM protocol but in that case these firms confront with an environment that other project participants still implementing available specifications and this situation makes it a challenging issue for the firm to deal with in a market that other project participants still work with available specifications. This situation causes practical handicaps that in this study these practical handicaps are tried to be unveiled. Considering the scenario argued in Chapter 4, findings and discussions are listed as follows:

- Insufficiency of the current legal system to provide guidance to AEC industry practices were emphasized in 10th Development Plan 2014-2018 Sector Report in 2013 (TCKB, 2013). Considering the recommendations provided in that document, and findings of this study, in order to provide guidance to current AEC industry practices, BIM protocols and national BIM standards should be prepared and released to be used in industry.

- Approach of CAT to party definition is similar with CIC BIM protocol approach. On the other hand, AIA BIM protocol provides more integrated and collaborated project participant relation than CIC BIM protocol. Considering the features of each BIM protocol and requirements of AEC

industry in Turkey, a party approach, which could be also implementable in regional and global perspective, should be revised and prepared in terms of working with BIM. This issue also mentioned in sector problems section of 10th Development Plan (TCKB, 2013).

- It is a general finding for the all key BIM terms that not take place in CAT - Architectural Service Specification have potentials to cause conflicts among project participants. This is due to fact that both Turkish AEC industry is not familiar the terms and due to non-existence of those terms in legal documents there is a legal insufficiency to compensate the AEC industry in case of conflict.

- Due to non-existence of official guiding documents in Turkish AEC industry, industry practitioners suffer from lack of knowledge, professional experience and official support. This situation causes a BIM implementation challenge for the firms in Turkey in which the firms are forced to find a way out in between traditional practices and BIM potentials.

- Considering the comparison and evaluation studies, it is possible to categorize key BIM terms, in terms of being familiar to the sector. This study is illustrated in Table 53. Although, other terms have a kind of background, model sharing, model reliability, interoperability, BIM execution planning, BIM project reviews and model element authorship are new BIM terms for Turkish AEC industry. Furthermore, there is no official explanation for them. Thus, it is a challenging issue for the firms adopting other countries BIM protocols that they both explain and agree with other project participants on these BIM terms.

- Considering the categorization stated in Table 53, the key BIM terms having a kind of background or having similarity with the items of CAT – Architectural Service Specification, have potentials to be established upon methods of traditional practice. There are two support for this argument in

this study. Firstly, these key BIM terms having background practices in the industry were evaluated and discussed in Section 4.4 of Chapter 4. Available circumstances that the firms confronting are framed in this section. It is mentioned that there is no official release for BIM terms in Turkey. This means that available knowledge in the market established by practical knowledge. Secondly, it is mentioned in handicaps of BIM that BIM provides new business relation and practices to the industry that brings resistance of staff to these changes. When this two experience are combined, it is resulted that this situation has potentials to cause observation of resistance to change the available practical knowledge in the firms when these key BIM terms are defined and released to the market officially.

Table 53. Categorization of Key BIM terms in terms of having background in Turkish architectural practice.

Key BIM Terms	**Having Background in Turkish Architectural Practice**
Model Development and Responsibilities of Parties	As indicated in comparison and evaluation section, this item has a kind of background in CAT – Architectural Service Specification.
Model Sharing and Model Reliability	There is no background in CAT – Architectural Service Specification.
Interoperability / File Format	There is no background of this item in CAT – Architectural Service Specification.
Model Management	As indicated in comparison and evaluation section, this item has a kind of background in CAT – Architectural Service Specification.
Intellectual Property Rights	As indicated in comparison and evaluation section, this item has a kind of background in CAT – Architectural Service Specification.
Requirement for BIM Execution Planning	There is no background of this item in CAT – Architectural Service Specification.
BIM Project Reviews	There is no background of this item in CAT – Architectural Service Specification.
Model Element Authorship	There is no background of this item in CAT – Architectural Service Specification.

5.1 Validation of the Findings

In order to validate the results derived from comparison and evaluation Section of 4.4 and 4.5, a survey was conducted with the firms whose were participated the BIM maturity assessment study. Office #3 and #6 replied to the survey. The same key BIM terms are given to the Office #3 and Office #6 as a title and their experiences and thoughts about the titles are asked. Furthermore, their applications and methods to fulfill the gaps due to non-existence of these titles in Turkish practice are also asked to the participants. The collected data from the participants are given in the following sections and at last section, the findings of evaluation and comparison and, findings of this section are compared.

5.1.1 Collected Data

Official Documents Used in Practice

- **Office #3**

- Chamber of Architects of Turkey (CAT) Architectural Service Specification

- Municipal Specifications

- Ministry of Environment and Urbanization

- **Office #6**

- AIA BIM Practice Documents,

- BIM Project Execution Planning Guide V2.1 BS 1192 - Pennsylvania State University

Parties Mentioned in the Documents

- **Office #3**

- Architect
- Employer/Owner

- **Office #6**

- Administration
- Building Control Officer
- Contractor
- Architectural Design Firm

Model Development & Responsibilities of Parties (AEC UK Initiative, 2012; CICRP, 2010)

- **Office #3**

Every participant that providing model to central model is responsible for what they are provided. Checking and monitoring these models are executed by the architectural firm. There is no continues improvement of model development integrated with other disciplines. When a change is occurred in architectural design model, then other disciplines are informed to update their models.

- **Office #6**

The model development and responsibilities of parties are defined at initial phases of project and represented with a matrix.

Model Sharing and Model Reliability (CICRP, 2010)

- **Office #3**

Based on the duties and responsibilities of parties stated in CAT documents, project participants provide warranty to the submitted model. Having the same information sharing and privacy of information concern stated in CAT documents, project participants continued their workings. Having the IPR of each model element, every participant obey and follow the rights provided by IPR depicted in CAT documents.

- **Office #6**

Model sharing method are described according to the standards

Interoperability / File Format (CICRP, 2010)

- **Office #3**

"IFC, ACIS, FBX" are the file formats that enable interoperability options with other disciplines.

- **Office #6**

"nwf, nwd, rvt" are the file formats that enable interoperability options with other disciplines.

Model Management (AEC UK Initiative, 2012; CICRP, 2010)

- **Office #3**

Model management is monitored and executed by the chef architect of the project team. However, there is no any standard method or guide to follow the process. All management procedure is based on practical experience and current necessities.

- **Office #6**

Under the control of BIM manager, the model is managed upon central model in accordance with model development procedures stated in AIA and NBIMS documents.

Intellectual Property Rights (IPR) (AEC UK Initiative, 2012; CICRP, 2010)

- **Office #3**

As stated in CAT – Architectural Service Specification Document, the owner of the architectural design firm has the intellectual property rights of every projects produced in this firm.

- **Office #6**

It is a common practice in Turkey that, the intellectual property rights of mechanical and electrical engineering IPR is owned by owner by agreeing on the contract.

Requirement for BIM Execution Planning (AEC UK Initiative, 2012; CICRP, 2010; CURT, 2010)

- **Office #3**

There is no applied standard form of BIM execution plan. Considering the practical background that the firm has, each project is planned, guided and executed without any written plan and diagram.

- **Office #6**

It is a necessity to preparing a BIM execution planning. Otherwise, it is possible to confront with chaotic situations in project development and responsibilities of project participants. The firm apply standard form of BIM execution plan provided by NBIMS.

BIM Project Reviews (AEC UK Initiative, 2012)

- **Office #3**

There are no BIM project reviews applied in this firm.

- **Office #6**

The firm participate coordination meetings. The related part of coordination meetings for the firm covers four topics. These are review of data derived from models, model consistency control, control of standard and clash detection. Following the model submissions of participants, the meetings are organized.

5.1.1.1 Model Element Authorship (AEC UK Initiative, 2012)

- **Office #3**

Every project model participant is the author of what he/she is generated and submitted to central model.

- **Office #6**

Every participant is author of what he/she is generated in the central model.

5.1.2 Comparison and Analysis of Collected Data with Findings

Official Documents Used in Practice

- **Scenario -1**: Office #3 proved that firms are executing their working process in comply with mainly CAT-Architectural Service Specification document.
- **Scenario -2**: Office #6 proved that firms are adopting and implementing official documents released in other countries due to the non-existence of official documents released in Turkey.

Parties Mentioned in the Documents

- **Scenario -1**: Office #3 stated that party approach in contracts are same with CAT – Architectural Service Specification.
- **Scenario -2**: Office #6 showed that party approach is same with party approach presented in selected foreign country official document.

Model Development & Responsibilities of Parties (AEC-(UK)-Initiative, 2012; CICRP, 2010)

- **Scenario -1**: Due to non-existence of model development & responsibilities of parties issues in CAT documents, Office #3 develop its own method based on the background information derived from passed experience to deal with model development issue. On the other hand, about responsibilities of parties, the firm apply a responsibility sharing method similar with AIA approach, which every project participant that providing model to central model has their own responsibility. When a change or revision occurs, the related project participants are informed and central model updated accordingly. However, this is not a written practice and is not took place in any official document such as contracts.
- **Scenario -2**: According to the procedure stated in AIA documents, model development and responsibilities of parties are identified in initial phases of project development.

Model Sharing and Model Reliability (CICRP, 2010)

- **Scenario -1**: Due to non-existence of any model sharing and model reliability issue in CAT documents, the firm developed its own way based upon the past experiences.
- **Scenario -2**: Model sharing and model reliability is provided according to the NBIMS standards.

5.1.2.1 Interoperability / File Format (CICRP, 2010)

- **Scenario -1**: Although there is no statement in CAT documents about interoperability / file format, Office #3 uses the following file formats in their practices: “IFC, ACIS and FBX”. This means that the firm apply to use standard file formats to better work with other firms in digital environment.

- **Scenario -2**: The Office #6 uses file formats of "nwf, nwd, rvt" which enables BIM working platforms. However, these are software specific file formats and can only work in same version of same software. It is impossible to work with these file formats with other BIM software.

Model Management (AEC UK Initiative, 2012; CICRP, 2010)

- **Scenario -1**: Due to non-existence of any model management description and procedure, office #3 manage the model according to the current needs, submissions and project phases stated in CAT documents.
- **Scenario -2**: Office #6 manage the model in compliance with the model development procedure described in AIA and NBIMS documents.

Intellectual Property Rights (IPR) (AEC UK Initiative, 2012; CICRP, 2010)

- **Scenario -1**: IPR approach in Office #3 is same with IPR approach provided by CAT documents.
- **Scenario -2**: As being an engineering firm, Office #6 has different IPR approach that in practice that owner have opportunity to have the ownership of IPR of engineering projects. This is impossible in Turkey. However, this issue is open to agreement of project participants in AIA documents.

Requirement for BIM Execution Planning (AEC UK Initiative, 2012; CICRP, 2010; CURT, 2010)

- **Scenario -1**: Office #3 is not applying any standard form of BIM execution plan as it is expected due to non-existence of BIM execution plan in CAT documents. All procedure and working practices are planned and guided by working knowledge collected upon past experiences.

- **Scenario -2**: Office #6 utilizes standard form of BIM execution plan provided by NBIMS. Furthermore, utilization of BIM execution planning is essential for efficiently and successfully complete the projects.

BIM Project Reviews (AEC UK Initiative, 2012)

- **Scenario -1**: There is no BIM project review sessions or meetings organized in office #3 during the project execution.
- **Scenario -2**: The office #6 is setting and joining BIM project reviews meetings and sessions.

Model Element Authorship (AEC UK Initiative, 2012)

- **Scenario -1**: Due to non-existence of model element authorship in CAT documents, and in order to share the risk and responsibility of project, Office #3 develop a method which is similar with AIA model element authorship approach that every project participant is author of what he/she generated and submitted to central model.
- **Scenario -2**: Office #6 applies AIA model element authorship approach that every project participant is author of what he/she generated and submitted to central model.

In conclusion, in validation section of this study, by presenting and comparing the survey results derived from Office #3 and #6 according to the scenarios defined and utilized in evaluation section, the findings are validated. Only in "Interoperability/File format section represents unexpected result that instead of using 2D digital file extensions, Office #3 utilizes international standard file

extensions such as “IFC”. This validation is not only approving the findings of comparison and evaluation section but also providing a comprehensive look on application and working procedures of architecture and engineering firms in Turkey in BIM implementation perspectives. By making further survey with other firms, all of the key BIM terms and applications may be further examined.

CHAPTER 6

6 COMMENTS AND CONCLUSIONS

A BIM maturity assessment study is conducted and factors at background of deficit BIM maturity areas are unveiled, argued and evaluated. In order to better understand the practical handicaps caused by deficit BIM maturity areas in the sector, AIA and CIC BIM documents are compared with CAT – Architectural Service Specification in terms of key BIM terms derived from best practice guides. Then an evaluation study is conducted considering two scenario which were observed among the firms during the BIM maturity assessment study. In order to validate the findings, the available applications of key BIM terms in these firms are asked to be explained again by the sample firms. Then the findings and collected data from last survey is compared and analyzed.

This is a characteristic of this study that conclusions of BIM maturity assessment study are supported and elaborated in comparison and evaluation study of AIA and CIC BIM documents with CAT – Architectural Service Specification document in terms of key BIM terms derived from best practice guides. It is concluded that:

- There is an immediate necessity to develop and prepare official BIM documents such as BIM standards, protocols and guides which will compensate the regulatory, contractual, product and services BIM maturity areas in Turkey.

- There are two type of BIM adoption in Turkey. One of them is not applying an official BIM documents due to non-existence and therefore,

implementing BIM with adopting BIM practices to available conditions shaped by both CAT documents and experienced knowledge. The other one is implementing BIM with adopting other countries BIM documents such as AIA and CIC BIM documents.

- For both BIM adoption type, the conditions, challenges and experiences of the firms are examined, discussed and analyzed with key BIM terms derived from best practice guides of United States and United Kingdom. It is concluded that, for the first type of BIM adoption, there is no equivalent application take place for the following terms; model development and responsibilities of parties, model sharing and model reliability, model management, requirement for BIM execution planning and BIM project reviews. Furthermore, for the following terms, there is no adequate application take place in the first type of BIM adoption; interoperability / file format, intellectual property rights, model element authorship.

- The biggest challenge for second type of BIM adoption is that although firm is applying an official BIM document, other firms in Turkey is not applying and this situation causes a gap between the firm implementing second type of BIM adoption and other firms implementing first type of BIM adoption.

- Furthermore, it is also another challenge for both type of BIM adoption that, BIM adoption is not widely recognized and accepted in Turkish AEC industry that makes it hard for implementing and sustaining BIM adoption efficiently. Especially, official entities have no idea about BIM practices because there is no study conducted by official entities.

- The firms in first scenario, for compensating necessary BIM actions that is not take place in official architectural service documents, develop their own

way of actions shaped by past practical experiences. As represented in initial sections, some of the actions are similar with official BIM documents and some of them is not. Lack of standard methods for such things eventually may cause inconsistent working procedure that is changing in every problem and conflict arouse.

- Lack of standards in BIM implementation areas may cause inefficient use of BIM.

- While it is a still handicap for BIM adoption of having legal issues even in United States and United Kingdom, lack of official background of BIM implementation in Turkey may cause gaps during the case of conflicts arousing in AEC industry. As a result of this situation, there may be confronted with inadequate and unfair judgement of courts.

Although each firm represent its own maturity score during the BIM maturity assessment, the objective of this study was investigating the common characteristics of these firms. The results of the firms show that without considering the location of the firm, firm size and market, there are common weak and common strong BIM maturity areas. Therefore, common characteristics of these firms motivate the study to generalize results as representative of BIM implementation practices in Turkey

The theoretical framework in this research established upon field data. The firms used in BIM maturity assessment study are giving service in different location, market and having different organizational scale. Deriving common characteristics of these firms although having these differences, make this research very special to work. Therefore, findings of BIM maturity assessment study may be further used in other studies related with BIM implementation in Turkey.

Although network is the fourth weakest BIM maturity area in this study, there is no further study taken place in order not to get out of the objectives of the research. Further researches may be conducted to deeply study and analysis the performance of network in BIM implementation practices in Turkey.

BIM maturity assessment study conducted with seven firms in Turkey. Further maturity assessment studies may be conducted in order to extend the findings of this study.

In order to establish the theoretical framework of this research upon field data, BIM maturity assessment study is conducted with 7 firms. The findings of BIM maturity assessment study may be used in other researches also due to origin of the data derived from real practices of Turkish firms.

As a result of this research findings and conclusions, it is tried to establish a comprehensive study which may guide and address further Turkey specific BIM adoption and implementation researches. It was the main motivation for this study to collect, examine and analyze field data and then establish a valid BIM implementation and BIM maturity platform for working upon by further researches.

Another noteworthy work taken place in this study is comparison and evaluation of AIA and CIC BIM Protocols with CAT – Architectural Service Specification regarding key BIM terms collected from best practice guides. The comparison section not only express the approach differences of AIA and CIC BIM Protocol but also shows the weak sides of Turkish practices. In order to better study the approach, application and practical differences of CAT documents with AIA and CIC BIM documents, further studies may be conducted. However, Chapter 4 of this research could be used as a reliable basis to start these studies.

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