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Improving Building Information Modeling (BIM) Implementation throughout the Construction Industry

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ABSTRACT

Building Information Modeling (BIM) is extensively used in the construction industry due to its benefits throughout the Project Life Cycle (PLC). BIM can simulate buildings throughout PLC, detect and resolve problems, and improve building visualization that contributes to the representation of actual project details in the construction stage. BIM contributes to project management promotion by detecting problems that lead to conflicts, cost overruns, and time delays. This work aims to implement an effective BIM for the Iraqi construction projects' life cycle. The methodology used is a literature review to collect the most important factors contributing to the success of BIM implementation, interview the team of the Central Bank of Iraq (CBI) building, and strive to improve the BEP of the CBI building. However, previous studies indicate collaborative work and communications enhance effective BIM implementation, which can improve BIM use by applying a BEP and an AEC (UK) BIM protocol that leads to positive BIM impact. BEP comprises important information and goals related to the intended project, including the BIM collaborative process (process map), information exchange requirements, BIM data management, BIM model management, and quality control, which are considered essential for enhancing BIM collaboration during PLC. This paper concludes that implementing BIM effectively requires overcoming obstacles faced by Iraqi construction projects. Effective BIM implementation requires improving collaboration and communication throughout the construction process, which could be achieved by depending on the BIM Execution Planning Guide(BEP Guide) and the AEC (UK) BIM Protocol 2012 V2.0.

Keywords: BIM Implementation, BIM Awareness, Collaboration, Clash detection, BIM uses requirement.

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تحسين تطبيق تقنية نمذجة معلومات البناء(BIM) في الصناعة الانشائية

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الخلاصة

أصبحت نمذجة معلومات البناء(BIM) ثورة في عالم صناعة البناء بسبب فوائدها طوال دورة حياة المشروع. نمذجة معلومات البناء(BIM) لها القدرة على محاكاة المباني خلال دورة حياة المشروع ، واكتشاف المشاكل وحلها وتحسين تصور المبنى الذي يساهم في تمثيل تفاصيل المشروع الفعلية قبل مرحلة البناء ، كما تساهم نمذجة معلومات البناء(BIM) في تعزيز إدارة المشاريع من خلال اكتشاف المشكلات التي تؤدي إلى التعارضات وتجاوزات التكاليف والتأخيرات الزمنية. لذلك ، تهدف هذه الورقة إلى التنفيذ الفعال لنمذجة معلومات البناء(BIM) طوال دورة حياة مشاريع البناء العراقية. لذا ، فإن المنهجية المستخدمة هي مراجعة الأدبيات لجمع أهم العوامل التي تسهم في نجاح تطبيق نمذجة معلومات البناء(BIM) واجراء مقابلات مع فريق البنك المركزي العراقي لتحسين خطة نمذجة معلومات البناء التي ستساعد فرق التخطيط على اتباعها عند تطبيق تقنية نمذجة معلومات البناءBIM.. اشارت الدراسات السابقة إلى أهمية العمل التعاوني والتواصل بين أصحاب المصلحة والتي يمكن تحسينها من خلال تطبيق خطة تنفيذ (BEP) BIM والمعايير التي تعمل على تحسين تأثير الإيجابي لنمذجة معلومات البناء (BIM). حيث تشمل خطة تنفيذ نمذجة معلومات البناء أفضل الممارسات البيئية ومعلومات وأهداف المشروع المعني وعملية BIM التعاونية (خريطة العملية) ، ومتطلبات تبادل المعلومات ، وإدارة بيانات BIM ، وإدارة نماذج BIM ، ومراقبة الجودة ، والتي تعتبر ضرورية لتعزيز العمل التعاوني لنمذجة معلومات البناء خلال دورة حياة المشروع. تستنتج هذه الورقة ان تنفيذ نمذجة معلومات البناء (BIM) بشكل فعال يتطلب التغلب على العقبات الموجودة في المشاريع الأنشائية العراقية وأن التنفيذ الفعال ل BIM يتطلب تحسين التعاون والتواصل طوال عملية البناء والتي يمكن تحقيقها خلال الاعتماد على معاير نمذجة معلومات البناء (BIM) ودليل تخطيط تنفيذ نمذجة معلومات البناء (BIM).

الكلمات المفتاحية: تنفيذ نمذجة معلومات البناء, التعاون, الوعي بنمذجة معلومات البناء, كشف التعارضات, متطلبات استخدام نمذجة معلومات البناء.

1. INTRODUCTION

BIM is the process that can store, generate, exchange, manage, and share information about buildings in an interoperable and reusable way **(Vanlande et al., 2008)**. **(Lutra, 2010)** referred to using BIM technology as allowing an accurate virtual 3D construction and parametric model that belongs to a building, containing information to support construction, fabrication, and procurement activities that are necessary for the building processes and have precise geometry. **(Shourangiz et al., 2011)** found that BIM comprises a concept that includes tools such as software and processes that integrate all required information about projects and data during PLC. **(Eastman et al., 2011)** described BIM as a modeling technology that has a set of processes to communicate, produce, and analyze building models. **(Miettinen and Paavola, 2014)** found BIM is the mixing of technologies that are expected to increase inter-disciplinary collaboration and inter-organizational collaboration

throughout the construction industry with the expectation of improving the quality and productivity of projects throughout PLC. **(Hadzaman et al., 2016)** defined BIM as parametric modeling to enhance the project PLC through the relevant information and data sharing among the project team to improve the project outcomes **(time, cost, and quality)**. **(Abd AM, 2017)** refers to BIM as a tool that can detect conflicts and reduce change orders.
The Iraqi construction industry suffers from inefficient management at all stages of construction projects, leading to many change orders, cost overruns, delays, and many other problems throughout the construction process. Also, the Iraqi construction industry suffers from poor planning **(Abed et al., 2020)**, weakness in collaboration, ineffective communication **(Faris et al., 2022)**, and the issuance of change orders throughout the construction phase. This may be due to ignorance of new technology that simulates reality, planning, construction, and post-construction phases. BIM is considered a new technology that could overcome and resolve many problems throughout the project life cycle. BIM greatly impacts traditional construction project problems, like cost overruns, schedule delays, and quality issues **(Eastman, 2011)**. Applying BIM throughout the PLC improves project productivity and performance throughout construction. However, realizing BIM's benefits requires effective implementation throughout construction **(Dakhil, 2017).**
This research aims to overcome problems throughout the construction phase by adopting BIM new technology. This can be realized by identifying factors that contribute to effective BIM implementation throughout the Iraqi construction projects' life cycle, improving collaboration and communication, and identifying challenges that face the implementation of BIM.

2. METHODOLOGY

The method used to achieve the aim of the research depends on the following steps:

- Collection of data: Data was collected by depending on the literature review to identify factors contributing to the implementation of BIM and obstacles facing BIM according to previous studies.
- The project teams of the CBI building were interviewed to collect data about the BIM Execution Plan (BEP) adopted in the CBI building, including data about the adopted method for managing BIM goals.
- Developing the BEP of the CBI building according to the steps and contents of the (BEP Guide).

3. BIM USES REQUIREMENTS

BIM requires a set of requirements for effective implementation during the project lifecycle, thus contributing to achieving the desired benefits (**CIC, 2012).** Failure to realize these requirements reflects the benefits of BIM use **(Becerik-Gerber et al., 2012).** There are types of requirements that clients require to be able to apply BIM throughout the PLC **(Dakhil, 2017)**:

1. Staff can review 3D models.
2. Have an awareness of BIM authoring tools.
3. Determine the optimum level of detail (LOD) that may realize the project's benefits.
4. Technology (software and hardware)
5. A quality assurance system to check the deliverables of the design.
6. Role and responsibilities of the project team.

7. Collaboration.
8. The project planning team must know about construction project scheduling.
9. The project team can use all n-D models.

4. MOTIVATION FOR BIM IMPLEMENTATION

Many drivers motivate the implementation of BIM. **(RIBA, 2012)** indicates that motivation for BIM implementation requires Enhancing approaches and collaborative methods within the design team, providing staff experience in the BIM field, using contract forms that are suitable for BIM uses, and using BIM according to the standards of BIM use **(Kekana et al., 2014)** found that enhancing BIM required providing BIM tools, support from government pressure, and coordination between all stakeholders throughout the project life cycle. **(Abbasnejad et al., 2016)** refer to BIM motivation as developing strategies that enhance cooperative work, resolve conflict, adopt new technologies, develop a plan for BIM implementation by the government, and provide training to expand BIM knowledge by depending on external organizations and experts in the BIM field. In Iraqi construction projects, the most important motivation factors were realizing stakeholders' BIM benefits and providing free courses about BIM are considered motivational factors. **(Hatem et al., 2018)** found educational curricula, increasing BIM benefits awareness, and contracting with BIM experience in the BIM field.

5. EFFECTIVENESS OF BIM IMPLEMENTATION

Factors that contribute to BIM implementation are developed to conduct further empirical studies. A summary of the previous work involving different factors concerning BIM is given in **Table 1**.
Adoption of BIM in the AECO industry has been found, especially in promoting communication among participants of the project and collaboration among project stakeholders (via a common data environment) and extracting cost estimation and quantity take-off **(Acharya et al., 2008; Azhar et al., 2008; Arayici et al., 2011; Azhar, 2011; Eastman et al., 2011).**
(CDE) can reduce errors associated with inconsistent and uncoordinated project documents. **(Antwi-Afari et al., 2018)** indicated factors shared between countries, e.g., the UK, USA, and South Korea that contribute to the success of BIM implementation: collaboration in design, construction, and engineering; accurate visualization for design, planning, and coordination of construction works; enhancing knowledge management and the exchange of information; and improved site planning. These factors represent a core basis for creating a standard evaluation model for measuring the success of BIM implementation. (**Mehran, 2016; Caires, 2013**) indicate that effective BIM implementation requires improved awareness, communication, and collaboration**.** (**CIC, 2010)** indicates that successful BIM implementation requires comprehensive planning. The (BEP Guide) submits a valuable method that contributes to determine the fundamental requirements for implementing BIM effectively **(Hooper and Ekholm, 2010)**. This Guide has a structural procedure that simulates planning and enhances communication among the project team throughout the early phases of projects. **(Caires, 2013)** enabled project teams to strategize the implementation of a BIM under collaborative working procedures throughout the project process by proposing a BIM Execution Plan (BEP) framework.

Table 1. Summary of literature for factors that success BIM implementation

No.	Factors of the success of BIM implementation	Previous Work
1	Enhancing the knowledge management and exchange of information.	**(Pektas and Pultar, 2006; Chiu and Lan, 2005; Ozkaya and Akin, 2006)**
2	Collaboration among design, construction, engineering, and stakeholders throughout facility management.	**(Lu et al., 2015; Wu and Issa, 2015)**
3	Planning and coordination throughout construction works.	**(Eastman et al., 2011; Azhar, 2011; Arayici et al., 2011)**
4	Integrating design validation (clash detection)	**(Eastman et al. 2011)**
5	Accurate design of 3D visualization	**(Fox and Hietanen, 2007; Olatunji and Sher, 2010)**
6	Enhancing effective communication between all project teams	**(Acharya et al., 2006)**

6. OBSTACLES

Obstacles that prevent Iraqi construction projects from implementing BIM are in **Table 2.**

7. AEC (UK) BIM PROTOCOL 2012 V2.0

BIM Protocol V2.0, derived from the AEC (UK) initiative, targets improving management and sharing information during the design and production phases. It is based on the guidelines and framework defined by the British Standards documents **(AEC-UK, 2012).** Target to supply standards and methods that contribute to the construction industry's organization, development, and management information when applying BIM collaborative work **(Caires, 2013).** CDE represents a "collaborative working process" that efficiently allows data sharing, as Section (9) illustrates**.**

8. CONTENTS OF BIM PROJECT EXECUTION PLANNING GUIDE

The BIM Project Execution Planning Guide is a standard that includes the structure and framework necessary for enhancing the BIM collaborative process **(Caires, 2013).** This standard is issued by the BIM project execution planning BuildingSMART alliance™ (bSa) Project, which helps project teams create BIM strategies and develop BEP **(CIC, 2010).**
The guide indicates that fulfilling details and comprehensive planning lead to the successful implementation of BIM. In addition, this guide has designed a structured procedure for creating and implementing a BIM execution plan, as shown in **Fig. 1**, which includes the following:

1. Identify the value of BIM use throughout (PLC).
2. Creating the BIM execution process by designing process maps

3. Identify the BIM deliverables in the form of information exchanges.
4. Updating the project's infrastructure in the form of contracts, communication procedures, technology, and quality control to support the implementation as identified by **(CIC, 2010).**

Table 2. Obstacles of BIM Implementation.

No	Reference	Ranked obstacle of Iraqi construction project according to a sequence that is illustrated.
1	**(Hatem and Abbas, 2018)**	Weak in government efforts towards implementing BIM
2		The absence of experts in the BIM field
3		Lack of BIM benefits awareness.
4		The resistance to change is strong.
5		Weak training and education in government centers and universities.
6		Weak cooperation among multi-disciplines
7		The cost of employing additional staff and BIM specialists.
8		The rising cost of BIMs software and its updates
9		The need for strong Internet can accommodate the vast amount of information.
10	**(Mahdi and Mawlood, 2020)**	Lack of demand from customers or other companies for projects implemented using BIM technologies
11		Lack of support / Lack of BIM-related investments
12		Incomplete or absence of a national standard for implementing BIM
13		lack BIMs experts
14		People reject to learn / Habitual and social resistance to change
15		Continuous contracting with traditional methods (BIM requires special contracting conditions)
16		The benefits of BIM adoption are uncertainty
17		The rising cost of BIM software
18		The rising cost of additional staff
19		The rising cost of BIM specialists
20		Believing enough use of current technology

8.1 Identify BIM Goals and Uses

During the planning processes, it is important to eliminate the value of BIM use for the project and team members by defining the purpose (goals) of BIM implementation, as given in **Table 3**

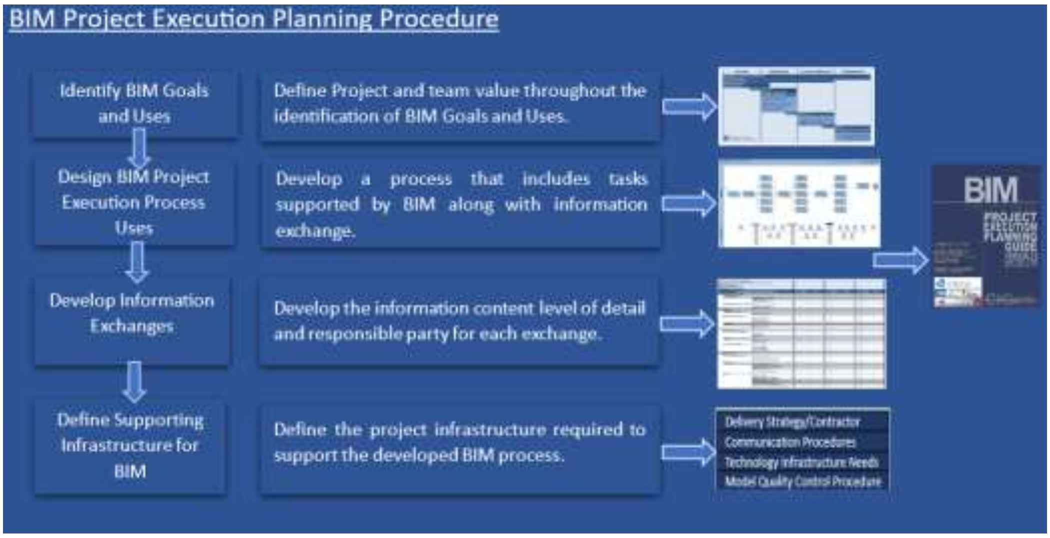


Figure 1. Structured procedures for creating and implementing BIM **(CIC, 2010)**

Table 3. Sample of BIM goals **(CIC, 2010)**

Priority Most Important	Goal Description Value added objectives	Potential BIM uses
1	Increase field Productivity	Design Reviews, 3D coordination
2	Increase the effectiveness of the Design	Design Authoring, Design Reviews, 3D coordination
3	Accurate 3D Record Model for FM Team	Record model, 3D Coordination
4	Increase the effectiveness of Sustainable Goals	Engineering Analysis, LEED Evaluation
5	Track progress during construction	4D Modeling
6	Review Design progress	Design Reviews
7	Quickly Asses the cost associated with design changes	Cost Estimation
8	Eliminate field conflicts	3D coordination

8.2 Designing the BIM Execution Process

After the team identified BIM uses, they started creating a process map for planning the requirements of BIM implementation in their projects, as shown in **Fig. 2.**
The steps required to create a process map, according to **(CIC, 2010),** are summarized as follows: However, **Fig. 3** illustrates the details of the process map.
1. Identify BIM use.
2. Indicate to the responsible party for each BIM process.
3. Identify the information exchanges that require implementation for each BIM use
Designing a process map requires using Business Process Modeling Notation (BPMN) **(CIC, 2010)**. BPMN includes a sample that is illustrated in **Fig. 4.**

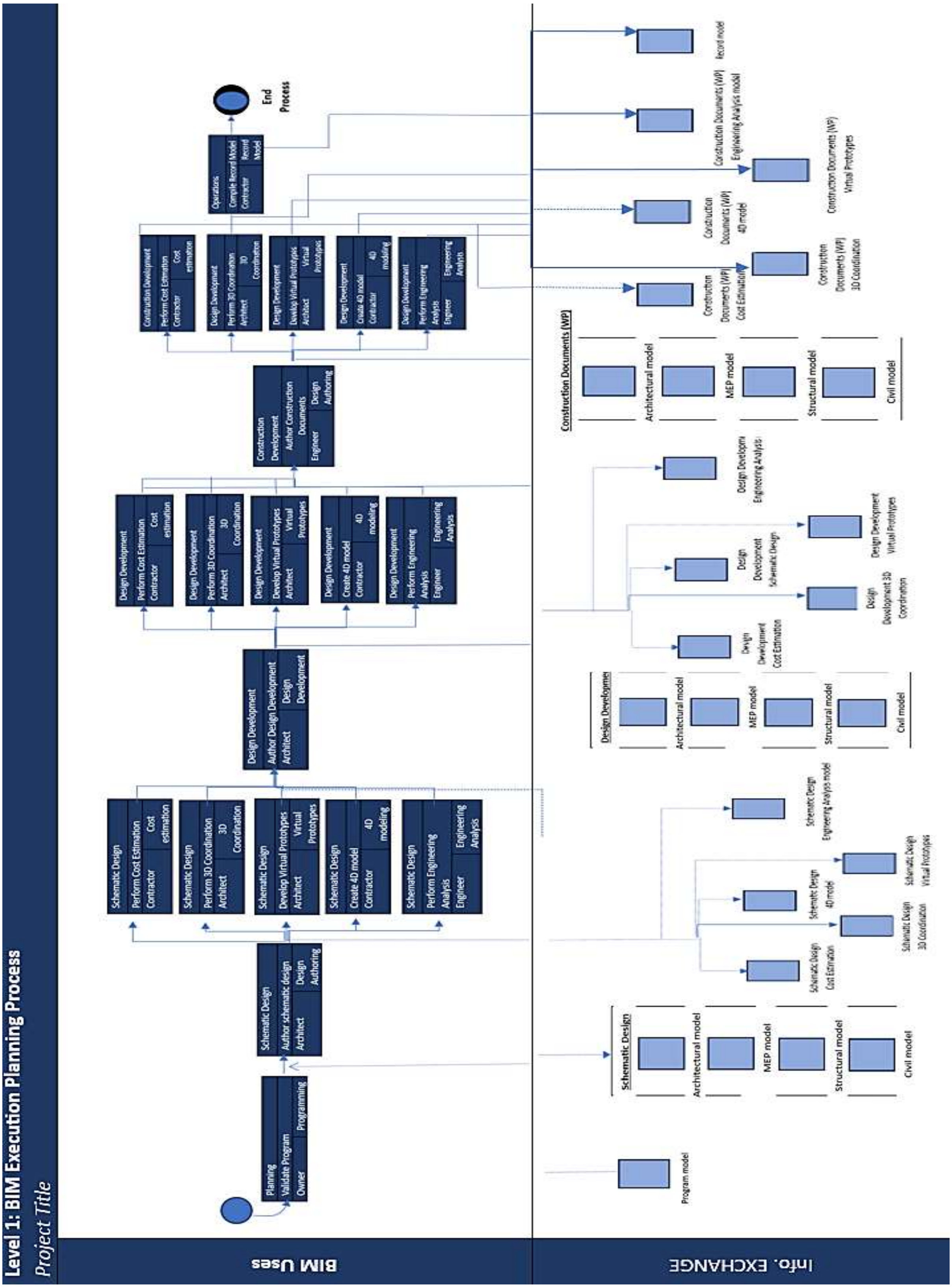


Figure 2. Sample of the process map **(CIC, 2010)**

Figure 3. Illustrate details of the process map. **(CIC, 2010)**

Element	Description	Notation
Event	An Event is an occurrence in the course of a business process. Three types of Events exist, based on when they affect the flow: Start, Intermediate, and End.	
Process	A Process is represented by a rectangle and is a generic term for work or activity that entity performs.	
Gateway	A Gateway is used to control the divergence and convergence of Sequence Flow. A Gateway can also be seen as equivalent to a decision in conventional flowcharting.	
Sequence Flow	A Sequence Flow is used to show the order (predecessors and successors) that activities will be performed in a Process.	
Association	An Association is used to tie information and processes with Data Objects. An arrowhead on the Association indicates a direction of flow, when appropriate.	
Pool	A Pool acts as a graphical container for partitioning a set of activities from other Pools.	
Lane	A Lane is a sub-partition within a Pool and will extend the entire length of the Pool - either vertically or horizontally. Lanes are used to organize and categorize activities.	
Data Object	A Data Object is a mechanism to show how data is required or produced by activities. They are connected to the activities through Associations.	Name
Group	A group represents a category of information. This type of grouping does not affect the Sequence Flow of the activities within the group. The category name appears on the diagram as the group label. Groups can be used for documentation or analysis purposes.	

Figure 4. Illustrate samples of BPMN that form the process map **(CIC, 2010)**

8.3 Information Exchanges Worksheet (IE)

Successful BIM implementation requires project teams to understand the information required for exchanges among project teams that are necessary for each BIM use. However, **Table 4** illustrates a sample of (IE). The exchange should identify information requirements for all parts of information and assign responsible parties, as shown in **Tables 5 and 6.**

Table 4. Sample of (IE) **(CIC, 2010)**

Information Exchange Title		
Time of Exchange (SD, DD, CD, Construction)		
Model Receiver		
Receiver File Format		
Application & Version		
A	SUBSTRUCTURE	
	Foundations	
		Standard Foundations
		Special Foundations
		Slab on Grade
	Basement Construction	
		Basement Excavation
		Basement Walls
B	SHELL	
	Superstructure	
		Floor Construction
		Roof Construction
	Exterior Enclosure	
		Exterior Walls
		Exterior Windows
		Exterior Doors
	Roofing	
		Roof Coverings
		Roof Openings
C	INTERIORS	
	Interior Construction	
		Partitions
		Interior Doors
		Fittings
	Stairs	
		Stair Construction
		Stair Finishes
	Interior Finishes	
		Wall Finishes
		Floor Finishes
		Ceiling Finishes
D	SERVICES	
	Conveying Systems	
		Elevators & Lifts
		Escalators & Moving Walks
		Other Conveying Systems
	Plumbing	
		Plumbing Fixtures
		Domestic Water Distribution
		Sanitary Waste

9. COMMON DATA ENVIRONMENT

The Common Data Environment (CDE) is an approach usually practiced throughout collaborative projects when BIM methodology is applied. The CDE is a data-sharing methodology that allows the sharing of information among all stakeholders and aims to reduce the revision, checking, and redirect cycle of data **(AEC-UK, 2012)**.

Table 5. Level of Detail of information

Information	
A	Accurate size and location, including materials and object parameters
B	General Size & Location, include parameter data
C	Schematic Size & Location

Table 6. Responsible parties

Responsible party	
A	Architect
C	Contractor
CV	Civil engineer
FM	Facility Manager
MEP	MEP Engineer
SE	Structural Engineer
TC	Trade Contractors

10. CASE STUDY

Indicates the BEP of the Central Bank of Iraq (CBI) as a case study that requires promotion according to the BIM Project Execution Planning Guide Version 2 **(CIC, 2010)** procedure. The following steps show how the BEP of the CBI building was developed according to the BIM Project Execution Planning Guide.

10.1 Project Information of the Case Study

When starting to implement BEP, the leading team should document the general project information of the CBI building to be a reference for stakeholders during PLC according to the BIM Project Execution Planning Guide as shown in **Table 7.**

Table 7. General project information of CBI.

Project name	Central Bank Of Iraq
Project Location	Jadiriya / Baghdad
Contract type	Owner contract with designer and contractor
Building Height	172m
Number of stories	37 floors
Work start date	10/01/2018
Work finish date	2024
Total project area	93552m2
Structure compounds	Basement, Podium, and Tower
Designer of projects	Zuha Hadid office
Contractor of project	DAAX Company

10.2 BIM Use

There are many uses for BIM during PLC. Identifying BIM use during the planning stage contributes to achieving project goals and improving process outcomes for the overall process. So, meetings with the responsible engineers of CBI include inquiries about the main purpose of using BIM on the CBI building, summarized according to the BEP guide procedure as shown in **Table 8.**

Table 8. BIM uses for CBI building.

ID	Project Goals	Potential BIM use
1	Clash detection to reduce construction cost	Design coordination
2	Benefit from the BIM model in facility management	Record modeling

10.3 Information Exchanges

Worksheets were used to fill out the information about BIM that required exchanges throughout the project life cycle. The information from the case study is filled in, as given in **Table 9** and follows the Project Execution Planning Guide Version 2.

Table 9. Information that required exchanges.

BIM USE Title		Design coordination				Design coordination		
Project stages		Planning				Design		
Information exchange Title (Output/Input)		Input				Output		
Model element		LOD	Resp party	Note		LOD	Resp party	Note
ARCH Elements								
Architectural sections						LOD 350	A	
Architectural elevation						LOD 350	A	
Architectural plan		LOD 350	A					
Interior partitions						LOD 350	A	
Wet areas						LOD 350	A	
Suspended ceiling plans		LOD 350	A					
Stairs, Ramps finishes						LOD 350	A	
Door schedule						LOD 350	A	
Landscape						LOD 350	A	
Signage						LOD 350	A	
Vertical Transportation						LOD 350	A	
Window schedule						LOD 350	A	
Architect metal work						LOD 350	MEP	
STR Elements								
HVAC Ducting						LOD 350	MEP	
HVAC piping						LOD 350	MEP	
Fire protection Installation						LOD 350	MEP	
Drainage installation						LOD 350	MEP	
Water supply Installation						LOD 350	MEP	

10.4 Process Map

Process maps contribute to the success of BIM goals for projects. It improves collaborative meetings, illustrates the level of detail, and shows the sequence of a process for the purpose of BIM use. All this is illustrated in BIM Project Execution Planning Guide Version 2.

The literature review indicates the design coordination process map includes a multidisciplinary process focused on management issues and decision-making, represents support for design development, and contributes to improving collaboration. However, **(Caires, 2013)** indicates that "design coordination" is fundamental to creating a more prolific workflow that is used to detect clashes between multi-disciplinary BIM models.
The process map detailed the CBI mentioned in the CBI BEP. The process map of CBI requires improvement to achieve BIM requirements. The CBI process map is shown in **Fig. 5**. The process map of CBI lacks responsibility for each participant and ambiguity in the sequence of the process. So, the process map of the CBI requires updating a design coordination process map in order to effectively manage clash detection among stakeholders.

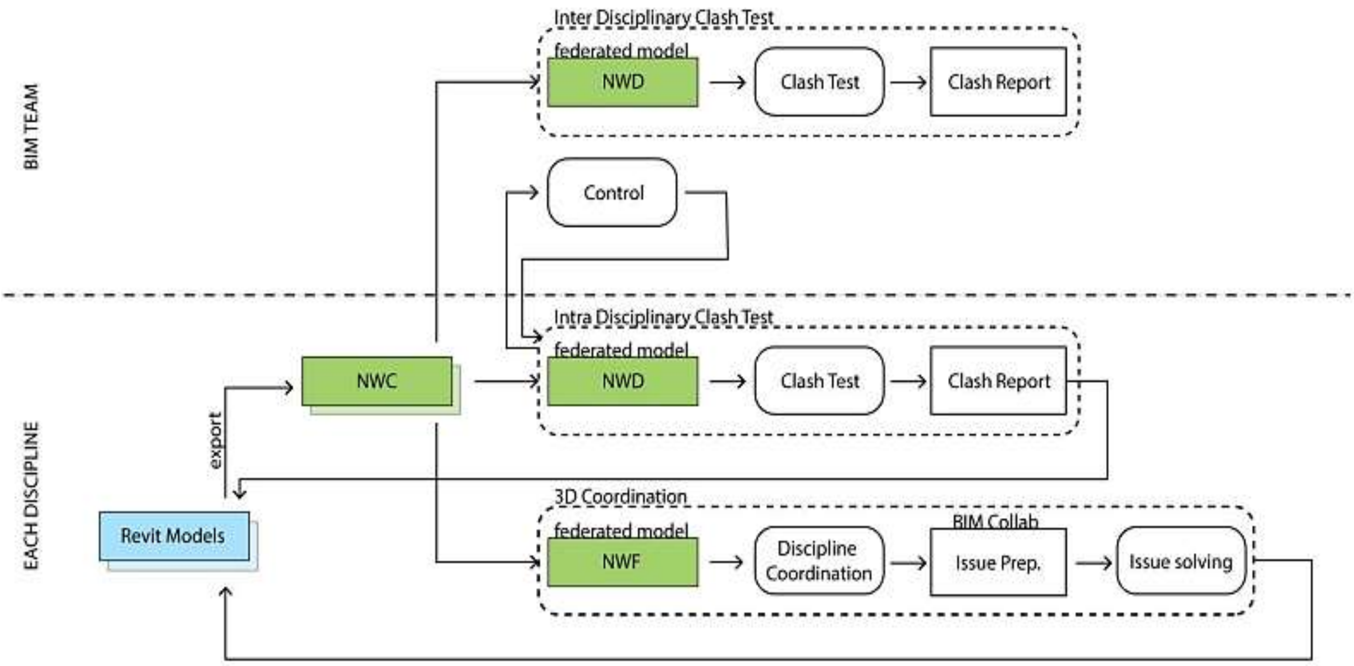


Figure 5. Process map of the CBI building. (BEP of CBI building)

11. UPDATING THE DESIGN COORDINATION PROCESS MAP OF CBI BUILDING

(CIC, 2010) of the Pennsylvania State University included a process map that illustrates how different BIM uses are intended; however, the process map includes details according to the special BIM uses that are intended. This process map was designed using Process Modeling Notation (BPMN). These maps can be found at the end of the (BEP Guide). The first step in updating a design coordination process map is arranged, as shown in **Figs. (6 to 10)** according to the required sequence that exists in the BEP of the case study. Then highlight important information and explain it under figures. This information contributes to creating a process map according to the (BEP Guide).

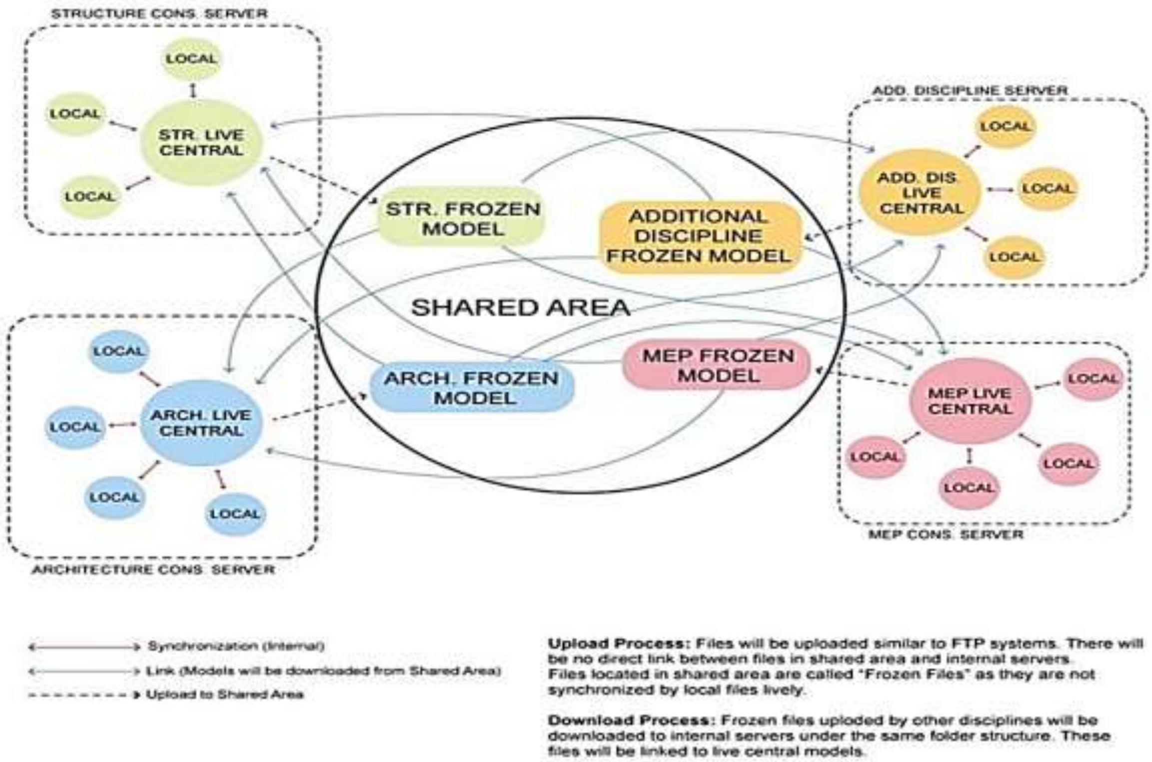


Figure 6. The models created for CBI building

2.16.2. Navisworks Assembly Process

Each discipline Clash Detection Coordinator will be responsible for exporting their discipline's models NWC format on a weekly basis. The discipline Clash Detection Coordinator will assemble these models into an updated project-wide NWF, for reference by the whole project team and inter-disciplinary CDVW on a regular basis.

Figure 7. Responsible parties for exporting NWC and assembling NWF for CBI building

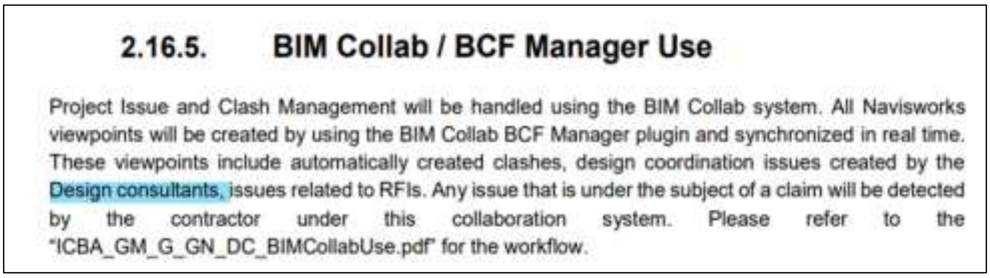
Design consultants will perform an intra-disciplinary clash report before each submission as part of QAQC process and intra-disciplinary clash detection on a regular basis. Inter-disciplinary Clash Detection Tests will be prepared by the BIM Management Team fortnightly and reports shared with every discipline. Spatial interferences will be detected with Navisworks between objects inside a model and with objects in other models. Models will be merged in Navisworks fortnightly for interactive review and mark-up during design review sessions.

Figure 8. Responsible for intra and inter-disciplinary clashes for CBI building

2.9.3.6. Clash Detection Parameter Group

The Clash Detection group contains the parameters that define the Clash Detection Matrix, which enable the 3D Coordination. These parameters establish the priority of the clash (A, B or C).

Figure 9. The benefit of creating the matrix for CBI building



2.16.5. BIM Collab / BCF Manager Use

Project Issue and Clash Management will be handled using the BIM Collab system. All Navisworks viewpoints will be created by using the BIM Collab BCF Manager plugin and synchronized in real time. These viewpoints include automatically created clashes, design coordination issues created by the Design consultants, issues related to RFIs. Any issue that is under the subject of a claim will be detected by the contractor under this collaboration system. Please refer to the "ICBA_GM_G_GN_DC_BIMCollabUse.pdf" for the workflow.

Figure 10. Reflect used BIM collaboration/BCF manager for CBI building

This information assists in updating the process map is divided into three parts: reference information, process, and information exchanges according to the (CIC, 2010) as shown in **Fig. 11**, which is illustrated as follows:

- The first part (the input part) includes information about modeling requirements.
- The second part includes the sequence of processes and indicates the responsibility of each person who participates in achieving BIM goals, illustrated as follows:

1) The sequence of architectural, structural, mechanical, electrical, and plumbing (MEP) models that were created by using BIM tools and identifies the responsibility of each person who participates in achieving BIM goals. (BEP of the CBI building)

2) After those export models in the NWC file by responsible persons to the person who is responsible for detecting clashes that are found in each discipline.

3) Assemble models by using Navis Work (NWF) to detect clashes among different disciplines by responsible persons.

4) If there are clashes or any collisions? If yes: sort the clashes according to importance (BEP of the CBI building), and then transfer the complete list of issues to the BCF manager, which is considered a tool for collaboration and communication among different disciplines, and reviewing issues individually to resolve issues after reaching to solution individually and by each discipline. After that, update the list of issues for resolution by each responsible discipline.

The third part includes information that is required to be exchanged among persons who are participants in achieving BIM goals.

12. RESULTS AND DISCUSSION

The work discusses factors that contributed to the successful implementation of BIM worldwide, so the literature indicates successful BIM implementation requires enhancing knowledge management, exchanging information, and collaboration among design, construction, engineering, and stakeholders throughout facility management. However, it required improving planning and coordination throughout the construction. Also, this paper identified obstacles that prevented BIM implementation in Iraqi construction projects, indicating the absence of government support, the absence of expertise, the lack of awareness of BIM benefits, the lack of knowledge and skills of company staff, weak training in education, government centers, and universities, and weak cooperation among

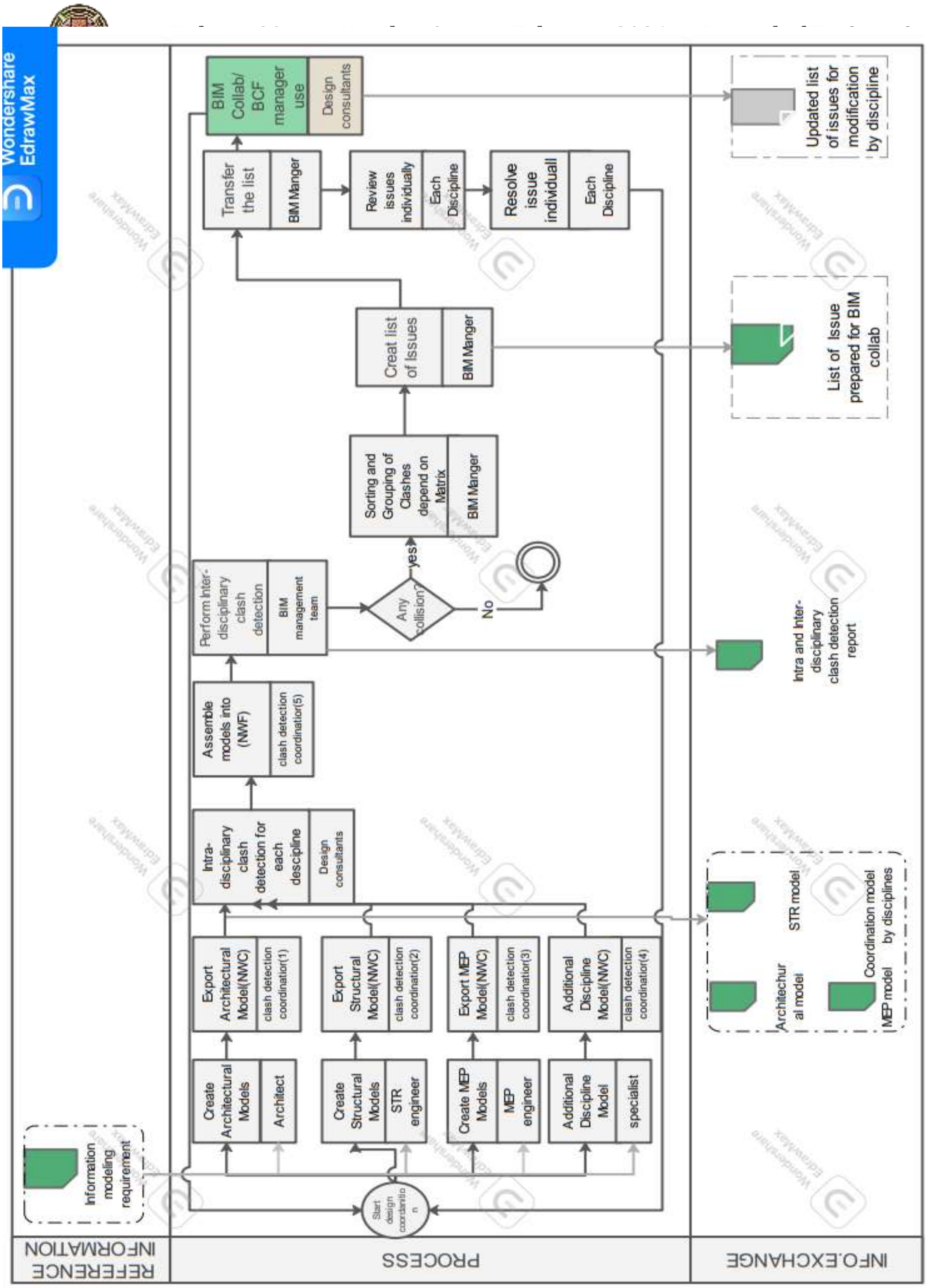


Figure 11. Details of updated design coordination process map of the case study.

multi-disciplines. BEP considers successful factors of BIM implementation, so developing the BEP of any project requires identifying general information, BIM goals and uses, and designing a process map according to the requirements of the goal of BIM implementation, the steps, and the content of the **(CIC, 2010).**

13. CONCLUSIONS

This work concludes that the effective implementation of BIM requires overcoming obstacles that face BIM in Iraqi construction projects and applying factors that contribute to the successful BIM implementation. However, previous studies indicated effective BIM implementation requires improving collaboration and communication throughout the construction process, which could be achieved by depending on the (BEP Guide) and the AEC (UK) BIM Protocol 2012 V2.0. The (BEP Guide) and AEC (UK) BIM Protocol 2012 V2.0 provide standards and methods that contribute to enhancing collaborative work among stakeholders throughout PLC that will assist all project teams in being aware of their responsibilities and assist the team in following and monitoring the progress of the project against the project plan. However, realizing BIM benefits requires effective BIM implementation.

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