

**PROCESS PROTOCOL FOR THE  
IMPLEMENTATION OF INTEGRATED  
PROJECT DELIVERY IN THE UAE:  
A CLIENT PERSPECTIVE**

**Mubarak Saad AL AHBABI**

**PROCESS PROTOCOL FOR THE  
IMPLEMENTATION OF INTEGRATED  
PROJECT DELIVERY IN THE UAE:  
A CLIENT PERSPECTIVE**

**Mubarak Saad AL AHBABI**

School of the Built Environment, College of Science and Technology  
University of Salford, Salford, UK

Submitted in Partial Fulfilment of the Requirement of the  
Degree of Doctor of Philosophy, May 2014

# ABSTRACT

The design, construction and commissioning of construction projects have been repeatedly mentioned as fragmented and inefficient. Much of the waste that is generated throughout the lifecycle of a building is mainly related to project stakeholders not having access to information that others have created. Most recently, there has been a focus on creating and reusing digital project information, throughout the lifecycle, to facilitate the exchange of information, which includes Building Information Modeling (BIM) and Integrated Project Delivery (IPD). The “low hanging fruit” advantage of BIM models is based on the production of coordinated and clash-free designs along which provide the ability to visualise building information in 3D. However, greater benefits can be achieved if organisations embrace BIM development into their work practices that can lead to higher levels of collaboration between project stakeholders. This can only be achieved through client-led initiatives, supported by clear and effective management tools, to manage change throughout the design and construction process.

The aim of this research is to develop a process protocol for the successful implementation of IPD in client organisations using BIM as the main vehicle to control and manage the integration process. The research focuses on the identification of high level processes and their inter-relationships, which could provide guidance to client organisations on how to implement and manage IPD effectively.

Three multi-storey buildings, in the United Arab Emirates (UAE), were selected as case studies. The first case was used as an exploratory study to validate the suitability of the proposed process protocol for the UAE’s local experiences and conditions, which has suffered from long delays and high cost overrun. As a “control case”, the study aimed to discover and investigate the real reasons behind the delays, their causes and how they could have been addressed adequately if BIM and IPD had been adopted. Case studies two and three involved on-going projects that implemented BIM from the early stages of the design phases but with different level of collaboration among the project stakeholders and were selected to ensure that the proposed process protocol is effective and can be implemented at different levels of collaboration, particularly in competitive tendering environments. Questionnaires were developed and semi-structured interviews were conducted with the client’s representatives, consultants and contractors focused on validating the various components of the process protocol throughout a project’s lifecycle.

The study shows that there is a lack of collaborative environment between various project stakeholders. Although the use of BIM has proven to be an effective tool, the success of collaboration can only be achieved with strong client leadership, trust and shared risk and rewards. However, local culture and contractual frameworks were found to be a major hurdle in achieving this aim. Client’s Legal Department can create and approve new type of contracts with the assistance of specially created BIM Office and Project Department. Client can take the driving seat by setting up a client committee to continuously review and monitor the project progress and to ensure that the proposed client’s requirements, plans and BIM strategy are accommodated in the project brief. With the presence of BIM, identifying BIM capabilities at early stage of the project are very important where the existence BIM management services were found to add a significant value to the successful implementation of BIM/IPD. Based on the University of Salford’s process protocol, this research produced a seven-phase process protocol, starting from strategy setting to operation (FM), to help client organisations to successfully adopt BIM/IPD. The process protocol is found to be the easiest tool, among others, to communicate the various roles and responsibilities to project stakeholders and ensures a strong client leadership is exercised throughout the design and construction process.

# ACKNOWLEDGEMENTS

I would like to express my deep gratitude to a number of people who have helped me throughout the course of this research study.

Firstly, words fail me when I try to acknowledge the support of Professor Mustafa Alshawi, who has, not only performed his formal role as a research supervisor, but continuously extended his assistance and encouragement as a big brother and a true friend. I remember with gratitude how he dedicated part of his personal and family time to review my research work, including weekends, public holidays and business trips, even sparing time during the course of long distance journeys.

Secondly, this research project would not have been possible without the steady flow of guidance and advice from my research mentor and local supervisor Dr. Marwan Jabakhanji. I am very much indebted to him for his significant inputs and insights on my dissertation from its inception until submission of the final thesis.

Last but not least, I would like to thank all those who provided me with the necessary data for this investigation, without whose help this research would not have been possible. They wish to remain anonymous, but you know who you are !

# DEDICATIONS

I am overwhelmingly honored to dedicate this dissertation work to H.H. Shaikh Khalifa bin Zaid Al Nahyan, President of the United Arab Emirates, whose distinguished leadership and guidance have inspired me to challenge myself with great determination and tenacity, and to His Highness Sheikh Mohammed bin Zayed Al Nahyan, the Crown Prince of Abu Dhabi, the Deputy Supreme Commander of the Armed Forces whose continuous encouragement and support for the country's youth to seek further knowledge and education was the prime incentive for me to pursue my postgraduate study.

I also dedicate this work to my loving parents to whom I owe special gratitude for their continuous support and encouragement for success in all of my academic pursuits. You have always been my best enthusiastic supporters.

I will not forget the encouragement and patience of my wife and wonderful children who accepted with tolerance my many periods of absence from home during the doctorate program.

## الاهداء

أتشرف بأن أهدي هذه الأطروحة بمنتهى الفخر والاعتزاز الى مقام صاحب السمو الشيخ خليفة بن زايد آل نهيان ، رئيس دولة الامارات العربية المتحدة ( حفظه الله ) ، الذي كانت قيادته وتوجيهاته المتميزة مصدر الهام لي لتحدي مقدراتي بكل عزيمة وإصرار ، والى مقام الفريق أول سمو الشيخ محمد بن زايد آل نهيان، ولي عهد أبوظبي نائب القائد الأعلى للقوات المسلحة الذي كان تشجيعه المستمر لابناء الوطن لتحقيق المزيد من العلوم والمعرفة دافعا وحافزا لي للسعي بكل جد ومتابعة الدراسات العليا .

كما أهدي هذه الأطروحة أيضا الى والدي الحبيين اللذين أدين لهما بامتنان خاص لدعمهما وحفزهما المستمر لي للنجاح في جميع المساعي العلمية. لقد كانا لي دائما خير المشجعين.

وبالطبع فأنني لن أنس التشجيع والصبر الذي تحلت به زوجتي وأولادي الرانعين الذين تقبلوا بطيب خاطر غيابي عنهم لفترات عديدة خلال العمل في اعداد رسالة الدكتوراة.

# DECLARATION

This thesis is presented as an original contribution based on Doctorate of Philosophy research at University of Salford, Salford, United Kingdom and has not been previously submitted to meet requirements for an award at any higher education institution under my name or that of any other individuals. To the best of my knowledge and belief, the thesis contains no materials previously published or written by another person except where due reference is made.

..... (Signed)

..... (Date)

# TABLE OF CONTENTS

ABSTRACT.....	ii
ACKNOWLEDGEMENTS .....	iii
DEDICATIONS .....	iv
DECLARATION .....	iv
TABLE OF CONTENTS.....	vi
LIST OF TABLES .....	xiii
LIST OF FIGURES .....	xiv
LIST OF ABBREVIATIONS .....	xv
CHAPTER 1 Introduction to the Research.....	1
1.1 Introduction.....	1
1.2 The Research Challenge .....	4
1.3 The Aims and Objectives of the Research.....	7
1.4 Research Design .....	9
1.5 Research Limitation .....	9
1.6 A Guide to the Thesis .....	10
CHAPTER 2 The Performance of the Construction Industry – Background .....	13
2.1 Introduction.....	13
2.2 The Economic Downturn and Client Demands .....	15
2.3 The Impact of Environmental Factors .....	17
2.4 The Impact of Advanced Technology .....	18
2.5 The Impact of New Procurement Methods .....	20
2.5.1 Design-Bid-Build (DBB).....	20
2.5.2 Design-Build (DB) .....	21

2.5.3	Partnering.....	22
2.5.4	Public Private Partnerships (PPP).....	24
2.6	Industry Performance and the Need for Improvement.....	24
2.7	The Main Challenges Facing the Industry .....	26
2.8	Summary .....	28
CHAPTER 3 Building Information Modelling (BIM) and Integrated Project Delivery (IPD) .....		29
3.1	Introduction.....	29
3.2	The Management of Project Information.....	30
3.3	Building Information Modelling (BIM) .....	32
3.3.1	Definition and Role of BIM.....	33
3.3.2	BIM Development in Design and Construction.....	34
3.3.3	UK BIM Strategy .....	37
3.3.4	BIM Implementation Plan .....	38
3.3.5	The Benefits of BIM to the Industry .....	40
3.3.6	Issues and Barriers .....	44
3.4	Roles and Responsibilities.....	48
3.4.1	Consultants .....	48
3.4.2	Contractors and Sub-Contractors.....	50
3.4.3	Clients .....	51
3.5	Collaborative Environment and BIM .....	52
3.6	The RIBA Plan of Work.....	53
3.7	Integrated Project Delivery (IPD) .....	56
3.7.1	The Principles of IPD .....	57
3.7.2	The Benefits of IPD .....	60
3.7.3	Differences between IPD and Traditional Procurement Approaches .....	62



3.7.4	Roles and Responsibilities .....	65
3.7.5	Risks, Legal Considerations and Reward Sharing .....	67
3.8	Challenges Facing the Implementation of IPD .....	68
3.9	IPD and Client Organisations.....	69
3.10	The Need for Tools to Transfer Client Organisations to BIM/IPD-Based Ones .....	71
3.11	Summary .....	72
CHAPTER 4 Process and Process Protocol .....		73
4.1	Introduction .....	73
4.2	Definition of a Business Process .....	74
4.3	Business Process Management .....	75
4.4	Process Modelling .....	76
4.5	Process Mapping .....	77
4.5.1	Data Flow Diagram .....	78
4.5.2	IDEFØ .....	80
4.5.3	Business Process Model and Notation (BPMN) .....	82
4.6	The Process Protocol (PP) .....	85
4.6.1	The Generic Design and Construction Process Protocol .....	86
4.6.2	Key Principles and Advantages of Process Protocol.....	87
4.6.3	Process Protocol Phases .....	90
4.6.4	Process Protocol Limitations .....	91
4.7	A Comparison of Process Protocol with other Techniques .....	93
4.8	Process Protocol and Client Organisations .....	94
4.9	Summary .....	94
CHAPTER 5 Research Methodology .....		96
5.1	Introduction .....	96

5.2	The Qualitative and Quantitative Approach .....	97
5.3	Case Study as Research Method .....	99
5.3.1	Case Study Categorisation.....	100
5.3.2	Advantages of Case Study Methodology .....	102
5.3.3	Disadvantages of Case Study Methodology.....	103
5.3.4	The Selection of Case Study as the Research Method.....	103
5.3.5	The Development of Process Protocol .....	106
5.3.6	The Case Study Design .....	107
5.4	Data Collection and Analysis Methods .....	109
5.4.1	Literature Review .....	109
5.4.2	Questionnaires .....	110
5.4.3	Interviews .....	111
5.5	Validity and Reliability Issues.....	113
5.6	Research Study Approach.....	114
5.7	Summary .....	117
CHAPTER 6: The Proposed Process Protocol .....		119
6.1	Introduction.....	119
6.2	The Assumptions Underpinning the Proposed Protocol .....	120
6.2.1	The BIM Management Office .....	121
6.2.2	The Process Protocol Components.....	122
6.3	The Process Protocol Phases.....	125
6.3.1	Phase 0: Strategy Setting.....	126
6.3.2	Phase 1: Project Requirements.....	129
6.3.3	Phase 2: Integrated Procurement .....	131
6.3.4	Phase 3: BIM-based Tender .....	134
6.3.5	Phase 4: Integrated Design.....	136

6.3.6	Phase 5: Construction .....	139
6.3.7	Phase 6: Operate (FM) .....	142
6.4	Summary .....	145
CHAPTER 7 Case Studies .....		146
7.1	Introduction .....	146
7.2	Presentation of the Case study.....	147
7.3	Case Study One .....	148
7.3.1	Project Description .....	148
7.3.2	Approach to Case Study One.....	149
7.3.3	Interviewees Background.....	151
7.3.3	Outcomes of Case Study One.....	153
7.3.4	Estimated Impact: Cost and Time .....	168
7.4	Case Study Two .....	169
7.4.1	Project Description .....	169
7.4.2	Approach to Case Study Two.....	171
7.4.3	Interviewees' Background .....	175
7.4.4	Case Study Two's Findings.....	176
7.5	Case Study Three .....	186
7.5.1	Project Description .....	186
7.5.2	Approach to Case Study Three .....	187
7.5.3	Interviewees' Background .....	188
7.5.4	The Outcomes of Case Study Three .....	189
7.6	Summary .....	198
Chapter 8: Discussion.....		199
8.1	Introduction .....	199
8.2	Key Findings – Case Study One.....	199

8.2.1	Client Leadership .....	200
8.2.2	BIM and Collaborative Environment (IPD) .....	200
8.2.3	Planning .....	203
8.2.4	Legal Contracts .....	203
8.3	First Alteration to the Process Protocol.....	203
8.3.1	New and Amended Processes .....	211
8.4	Key Findings – Case Study Two and Three.....	211
8.4.1	Client Leadership .....	212
8.4.2	Project Brief.....	213
8.4.3	Capacity/Maturity .....	214
8.4.4	Project Phase Decision .....	215
8.4.5	Facility Management .....	215
8.4.6	Contracts.....	216
8.4.7	Collaboration .....	217
8.4.8	BIM Management.....	218
8.4.9	BIM-Based Application .....	219
8.5	General Findings from Case Studies Two and Three .....	220
8.6	Backtracking the Findings of Case Studies Two and Three to the Process Protocol.....	221
8.7	Final Recommended Process Protocol.....	227
8.7.1	Phase 0: Strategy Setting.....	227
8.7.2	Phase 1: Project Requirements.....	229
8.7.3	Phase 2: Integrated Procurement .....	232
8.7.4	Phase 3: BIM-based Tender .....	235
8.7.5	Phase 4: Integrated Design.....	238
8.7.6	Phase 5: Construction .....	242

8.7.7	Phase 6: Operate (FM)	246
8.8	Summary	248
Chapter 9: Summary and Conclusions		249
9.1	Introduction	249
9.2	Summary	249
9.2.1	Background summary	249
9.2.2	Summary of Research Approach and Outcome	253
9.3	Key findings	256
9.4	Main Conclusions	260
9.5	Contributions to Knowledge	263
9.5	Recommendations for Future Work	265
BIBLIOGRAPHY		267
Appendix A: The Interview Questions for Case Study Two and Three		276
Appendix B: Process Protocol and Process Descriptions		289

# LIST OF TABLES

Table 3.1:	Example BIM Initiative Worldwide (Modified from BCA, 2011).....	36
Table 3.2:	BIM Applications for Project Stakeholders .....	43
Table 3.3:	Traditional Project Delivery Methods vs Integrated Project Delivery .....	64
Table 5.1:	The Differences between Qualitative and Quantitative Research .....	98
Table 5.2:	Justification for Selecting Research Method (Yin, 2009, p. 8).....	104
Table 5.3:	Types of Case Study Evidence (Yin, 2009, p. 102).....	108
Table 5.4:	Approaches of Open-Ended Interviews (Patton, 2005) .....	112
Table 5.5:	Validity and Reliability Procedures for Case Study (Yin, 2009, p. 41) ...	113
Table 7.1:	The Outline of the Presentation Structure of Each Case.....	148
Table 7.2:	List of Case Study One Findings.....	155
Table 7.3:	Cost and Time Implication on the Project.....	168
Table 7.4:	Estimated BIM/IPD Impact on the Project .....	168
Table 8.1:	Linking the Problem to the Process Protocol.....	205
Table 8.2:	Amended Process Protocol from Case Study One .....	211
Table 8.3:	Updated and New Processes after Case Study Two and Three .....	223

# LIST OF FIGURES

Figure 1.1:	Research Framework.....	8
Figure 2.1:	Labour Productivity in Construction and Non-Farm Industries.....	25
Figure 3.1:	The Prevailing Document Centric Communication Model.....	30
Figure 3.2:	Transforming Document Centric Model to Shared Project Model .....	31
Figure 3.3:	UK BIM Strategy Chart (BIM Industry Working Group, 2011) .....	37
Figure 3.4:	BIM Improves Ability to Control Costs.....	41
Figure 3.5:	BIM Benefits Study by CIFE (Kunz and Gilligan, 2007) .....	43
Figure 3.6:	RIBA Plan of Work 2007 (RIBA, 2007) .....	54
Figure 3.7:	RIBA Plan of Work 2013 (RIBA, 2013) .....	55
Figure 3.8:	IPD Survey Results by AIA and AGC.....	61
Figure 3.9:	Comparison Between Traditional Procurement and the IPD Approach	63
Figure 3.10:	The “MacLeamy Curve” IPD Impact on the Design Process.....	65
Figure 3.11:	The Three Levels of Collaboration .....	70
Figure 4.1:	Process Decomposition (British Columbia, 1996).....	75
Figure 4.2:	Basic Concept of Data Flow Diagram (DFD) (Edraw, 2014) .....	79
Figure 4.3:	Basic Concept of IDEFØ.....	81
Figure 4.4:	Business Process Model and Notation (BPMN) (Saluja, 2009, p. 47)..	83
Figure 4.5:	The Process Protocol Map (Kagioglou <i>et al.</i> , 1998a).....	89
Figure 5.1:	Project phases of the proposed process protocol .....	115
Figure 6.1:	Part of the Proposed Process Protocol .....	120
Figure 6.2:	The Proposed Process Protocol .....	123
Figure 7.1:	Case Studies Structure .....	147
Figure 7.2:	Approach to Case Study One .....	150
Figure 7.3:	Approach to Case Study Two and Three .....	171

# LIST OF ABBREVIATIONS

ACC	Airport Consultants Council
ACI-NA	Airports Council International-North America
AGC	Associated General Contractors of America
AIA	The American Institute of Architects
BCA	Building and Construction Authority of Singapore
BCIS	Building Cost Information Service
BIM	Building Information Modelling
BIT	BIM Implementation Team
BoQ	Bill of Quantities
BPF	British Property Federation
BPM	Business Process Management
BPMN	Business Process Model and Notation
BREEAM	Building Research Establishment Environmental Assessment Methodology
BS	British Standards
CAE	Computer Aided Engineering
CIE	Computer Integrated Environments
CIFE	Center for Integrated Facilities Engineering, Stanford Univ. USA
COAA	Construction Owners Association of America
COBie	Construction Operations Building Information Exchange
CPIC	Construction Project Information Committee
CRC	Cooperative Research Centres
CURT	The Construction Users Roundtable
DB	Design-Build
DBB	Design-Bid-Build
DECA	Danish Enterprise and Construction Authority
DFD	Data Flow Diagram



ECTP	European Construction Technology Platform
FM	Facility Management
GSC	Government Construction Strategy
ICAM	Integrated Computer Aided Manufacturing
ICT	Information Communication Technology
IDEF	ICAM Definition
IDEFØ	ICAM Definition Method Zero
IDM	Information Delivery Manual
IFC	Industry Foundation Classes
IPD	Integrated Project Delivery
IT	Information Technology
KPI	Key Performance Indicators
LEED	Leadership in Energy and Environmental Design
LoD	Level of Development
LOD	Level of Detail
MEP	Mechanical, Electrical and Plumbing
NAO	National Audit Office
NASFA	National Association of State Facilities Administrators
NBIMS	National BIM Standard
NEDO	National Economic Development Office
NIBS	The National Institute of Building Sciences
NIEP	National Improvement and Efficiency Partnership
NIST	The National Institute of Standards and Technology
NPD	New Product Development
O&M	Operation and Maintenance
OGC	The United Kingdom's Office of Government Commerce
OMG	Object Management Group
PM	Project Management
PMO	Project Management Office
PP	Process Protocol
PPP	Public Private Partnership

QA	Quality Assurance
QC	Quality Control
RFI	Request for Information
RIBA	Royal Institute of British Architects
RICS	Royal Institute of Chartered Surveyors
ROI	Return on Investment
SADT	Structured Analysis and Design Technique
SOM	Cranfield School of Management
STEP	STandard for the Exchange of Product model data
UAE	United Arab Emirates
UAED	UAE Dirham
UKCG	UK Contractors Group
USACE	U.S. Army Corps of Engineers
VA	U.S. Department of Veterans Affairs
VE	Value Engineering
XML	Extensible Markup Language

# **CHAPTER 1**

## **Introduction to the Research**

### **1.1 Introduction**

The construction industry is a multi-disciplinary and multi-national industry, which has an important role to play within the overall economy of any country. The construction industry also makes an important contribution to the competitiveness and prosperity of an economy when it plays a major role in delivering built infrastructure in an innovative and cost effective way. The 2009 report published by L.E.K Consulting for the UK Contractors Group (UKCG) highlighted that government investment in construction is the most beneficial use of simulative public expenditure whereby construction has an impact on economic activity, contributing to employment and providing benefits for the investment (UKCG, 2009).

The Egan's Report, with the aim of examining the efficiency of the construction industry, identified global areas for improvement estimating that only 40-60 percent of potential labour efficiencies are ever achieved: Up to 30 percent of the cost of construction is due to rework; 10 percent is due to material wastage and; accidents could account for as much as 3-6 percent of total project costs (Egan, 1998). The Report also proposed a radical transformation of the UK construction sector, identifying five key drivers of change: committed leadership, a focus on the customer, integrated processes and teams, a quality driven agenda, and a commitment to people. The adoption of a "lean" approach to design and construction projects to minimize waste across the board has also been recommended.

However, the construction industry has been repeatedly characterised as inefficient. Greater efficiency could achieve significant savings. Indeed it has been argued that such savings could add up to as much as 30 percent (Egan, 1998; Latham, 1994). Wasted effort is mainly caused by duplicated work in a complex supply chain, where

data used further down the supply chain has to be re-entered or re-created by other suppliers, largely because the software used by each party is not inter-operable. The National Institute of Standards and Technology (NIST) looked at this problem in the US in 2004 and estimated the total cost of inadequate inter-operability at \$15.8 billion per year, the equivalent of 2.84 percent of the annual financial value of the construction industry (2002 figures). Of these costs, two-thirds are borne by owners and operators, which incur during on-going facility operations and maintenance (O&M) (Gallaher *et al.*, 2004).

There are major challenges to an improved performance within the industry. Particularly lacking is, the ability to capture the large amounts of information generated during the lifecycle of projects and to make these available, in the right format, so that professionals can then evaluate alternative solutions based on lifecycle analysis. According to “the Investors Report” (BIM Task Group, 2012) the construction industry captures and retains little data about the assets it delivers and operates. The data that the sector does capture is rarely sufficiently analysed to allow performance on the existing project, or delivery of the next, to be improved. However, industry professionals are aware of the significant impact of having readily available project information during the design and construction.

The fragmented nature of the industry is the main reason behind the unavailability and ill utilisation of project information. Any construction project involves numerous practitioners, including architects, engineers, contractors, subcontractors and suppliers to deliver a one-of-a-kind project, which requires a tremendous amount of coordination. This involves the collaboration of a number of organisations, which are brought together for the duration of the project as the “project team”. These organisations vary in terms of size, capability, skills, practices, IT systems and many others. In addition, they are more often based in different locations yet they need to work collaboratively and share the same project information. This imposes a great challenge in meeting the projects’ objectives, in terms of time, cost, and quality, and most importantly, meeting client requirements through better collaboration between the project partners.

In addition, the Construction Users Roundtable (CURT) (2010) highlighted the difficulties experienced on typical projects as “artifacts of a construction process

fraught by a lack of cooperation and poor information integration". Typical problems cited included: errors, omissions, inefficiencies, coordination problems, cost overruns and productivity losses. Over the past decade, however, the industry has reacted to these challenges by adopting effective procurement approaches, such as partnering and design and build, in order to improve collaboration and communication among the projects' stakeholders.

Clients' involvement has long been recognised as an important driver to improve the industry's performance, and, more specifically, in stimulating innovation in design and construction (NEDO, 1975). However, the same report stated that:

*"Our case studies reveal widespread and conspicuous failure among public sector clients to give due regard to this"*

The lack of adequately engaging clients and managing their requirements contributes adversely to construction budget and schedule overruns. This is a difficult task to achieve, particularly if clients are not continuously and formally involved in the design and construction process, which means that the design intent is left to designers that may not always satisfy clients' requirements. Such a task needs to be managed sufficiently in order to enhance transparency towards clients' requirements and communication with all stakeholders throughout the lifecycle of a facility (Jallow *et al.*, 2008). In almost all cases, clients can take a lead by demanding and valuing good practice. Without this, lowest cost will probably drive out change until the situation is so severe that legislation is used to force action (Barrett, 2008).

Client lead is strongly recognised in bringing change through better collaboration between project stakeholders. However, one of the major challenges is that collaboration is operated under conventional procurement methods, which hugely limit the stakeholders' roles and responsibilities to bring about the required level of collaboration. Moreover, there is a resistance against adopting new enabling technologies, which are perceived as costly, and there is concern that there are insufficiently skilled workers who are incapable of using this technology effectively. In fact, the opportunities offered to organisations by such technologies require businesses to review and refocus how they add value to the design and construction process within this new business environment. They will also change the nature and

timing of how designs proceed as well as how and when client value is added to the design and construction process (Shen *et al.*, 2009).

Recently, the convergence of technology, culture and process has given birth to the notion of Building Information Modelling (BIM). According to HM Government (2012), Building Information Modelling (BIM) is defined as a collaborative way of working, underpinned by the digital technologies which unlock more efficient methods of designing, creating and maintaining our assets. Although relatively new to the construction industry, 3-D modelling in the sense of BIM, has been used in other industries for a significant period of time (Langdon, 2012b). The benefits of BIM have been highlighted in many publications for improving design and construction. Indeed BIM derives fundamentally from the way in which all parties to the project can contribute to the central data model and the way all can draw information from it. The issue here is not only leveraging IT hardware and software using BIM but also the creating of a collaborative environment for successful BIM deliverables. Until now, the questions of how such protocol for BIM/IPD should be structured and implemented effectively still remains to be investigated further.

## **1.2 The Research Challenge**

### ***The UAE Construction Industry***

The United Arab Emirates (UAE) construction industry has reached an unparalleled position in the last decade. It started to grow to meet the increasing demand for shelter, offices, electricity and roads amongst other infrastructure. The real boom, though, started in the mid-1990s with the shift from an oil-dependent economy to one which is more reliant on industry, commerce and tourism. The growth was initiated by the public sector but the private sector has also been involved. The Emirate of Dubai has been credited with the highest per square kilometre of construction activity in the world. Dubai's pivotal role in the recent expansion of construction activity in the Gulf is obvious: of the \$50 billion estimated Gulf-wide building spends, 60 percent of that, about \$30 billion is in the UAE alone; and the majority of that is in Dubai (ITP Construction, 2004).

Faridi and El-Sayegh (2006) identified the top 10 most significant causes of construction delays in the UAE, of which the key ones are the “approval of drawings”, “inadequate early planning” and “slowness of the owners' decision-making process”. This is related to the international nature of the industry in the UAE. In other words most of the working companies (consultants, contractors, sub-contractors and suppliers) are branches of international companies or local companies associated with international companies. Such a climate has advantages such as the diverse technology and experiences that can be brought to the local market via international companies. While the main disadvantage is that almost all companies base their business models on parochial benefits and gains rather than long-term plans. As a result, there is a lack of good investment in new technology and the development of human capital. This situation is further inflated by the:

- Lack of clear vision of most of the local clients;
- Very poor or no clear client briefs;
- Absence of quality engineering practice, i.e. local consultants pay low staff salaries while international consultants do not invest enough in developing local capabilities;
- Local laws and regulations (governmental and public works) are pro open biddings;
- Natural tendency to avoid innovative solutions in projects; and
- Lack of understanding of the collaborative environment among the engineering and construction community.

### ***BIM and Collaborative Environments***

The last decade has seen a vast emergence of BIM and related technologies to a point where they may now be considered as the recognised platform for the design and construction of many building projects. Their adoption has reached the ‘tipping point’ whereby their use may be expected to grow significantly over the next decade (Shen *et al.*, 2009).

Shen *et al.* (2009) describe BIM and related technologies as:

*“BIM and related technologies will inevitably improve productivity and reduce waste within the construction process, change the role of professionals within the process and when and how they contribute their knowledge and expertise, enable data on individual projects to be shared within other larger models of the built environment, re-engineer existing business processes, and require new types of software and new technologies”*

Eastman *et al.* (2011) define BIM as ‘a modelling technology and associated set of procedures to produce, communicate and analyse building models’ and characterise building models as intelligent digital representations of building components, which include data that describes how they behave. Brandon and Kocatürk (2008) explore how BIM and related technologies will present a new virtual future for design, construction and procurement.

It is widely recognised that BIM is becoming an important technological tool which can bring significant improvements to construction projects if implemented successfully. However, this technology, on its own, will not yield the full benefits, particularly to client organisations, if it is not underpinned by appropriate practices that harness its complete potential. These include process-based models and procurement systems that clearly define the level of collaboration through the roles and responsibilities of all project partners. However, a large percentage of BIM research is still focusing on the technological aspect including the inter-operability of BIM technologies. For example the works of Becerik-Gerber and Kensek, 2009; Björk and Laakso, 2010; Goedert and Meadati, 2008; Halfawy and Froese, 2005; Howell and Batcheler, 2005; Steel *et al.*, 2010.

The impact of the “process” on performance improvement is clearly understood by the industry’s leaders, i.e. the majority of the problems facing the construction industry are process related and not technology based (Kagioglou *et al.*, 1998). Taylor and Bernstein (2009) mentioned that the full benefit of BIM tools can only be captured by coordinating and developing integrated business practices. Kiviniemi *et al.* (2008) highlighted that there is a need to redefine the traditional work processes and roles that each partner must have in the future. The American Institute of Architect’s (AIA) report on integrated practice explains that “There is a lack of understanding on the part of industry participants on how to achieve integrated workflows through integrated technology” (AIA, 2006).



The AIA has been promoting a new approach to collaboration namely “Integrated Project Delivery” (IPD). The AIA (2010) has defined IPD as “a project delivery method distinguished by a contractual agreement between a minimum of the client, design professional, and contractor, where risk and reward are shared and stakeholder success is dependent on the project success”. In principle, IPD requires all project stakeholders to get involved in the project right from the early stages of the design process. A proactive approach needs to be taken by all stakeholders to prevent problems from occurring, rather than wait to solve them once they have materialised. In this approach, each stakeholder should be working in the best interests of the project and the client.

This research faces two main challenges: firstly BIM and its delivery process using IPD; and how client organisations can accommodate better and more effective processes in order to maximise the benefits achieved from BIM implementation. The latter is critical for effectively and efficiently transferring client organisations from the traditional delivery of projects into BIM/IPD ones.

### **1.3 The Aims and Objectives of the Research**

The primary aim of this research is to develop a process roadmap for the successful implementation of Integrated Project Delivery (IPD) for client organisations using BIM as the main vehicle to control and manage the integration process. The research will focus on the identification of high level processes and their inter-relationships, which could provide guidance to client organisations on how to implement and manage IPD effectively. The research will also seek to investigate their impact on UAE local culture and legal procurement framework on the implementation of BIM/IPD.

In order to achieve the above aims, the following objectives, summarized as follows, have to be achieved:

1. Develop an in depth understanding of BIM and IPD’s concepts and principles through carrying out a detailed literature review;
2. Understand the existing BIM/IPD drivers and challenges in client organisations;

3. Identify the main processes required to successfully implement BIM/IPD in client organisations;
4. Develop a process roadmap (process protocol) for implementing BIM/IPD in client organisations including the identification of its main components;
5. Evaluate the process protocol within UAE local culture;
6. Validate the process protocol using real case studies; and
7. Produce a recommended process protocol for client organisations along with its process details.

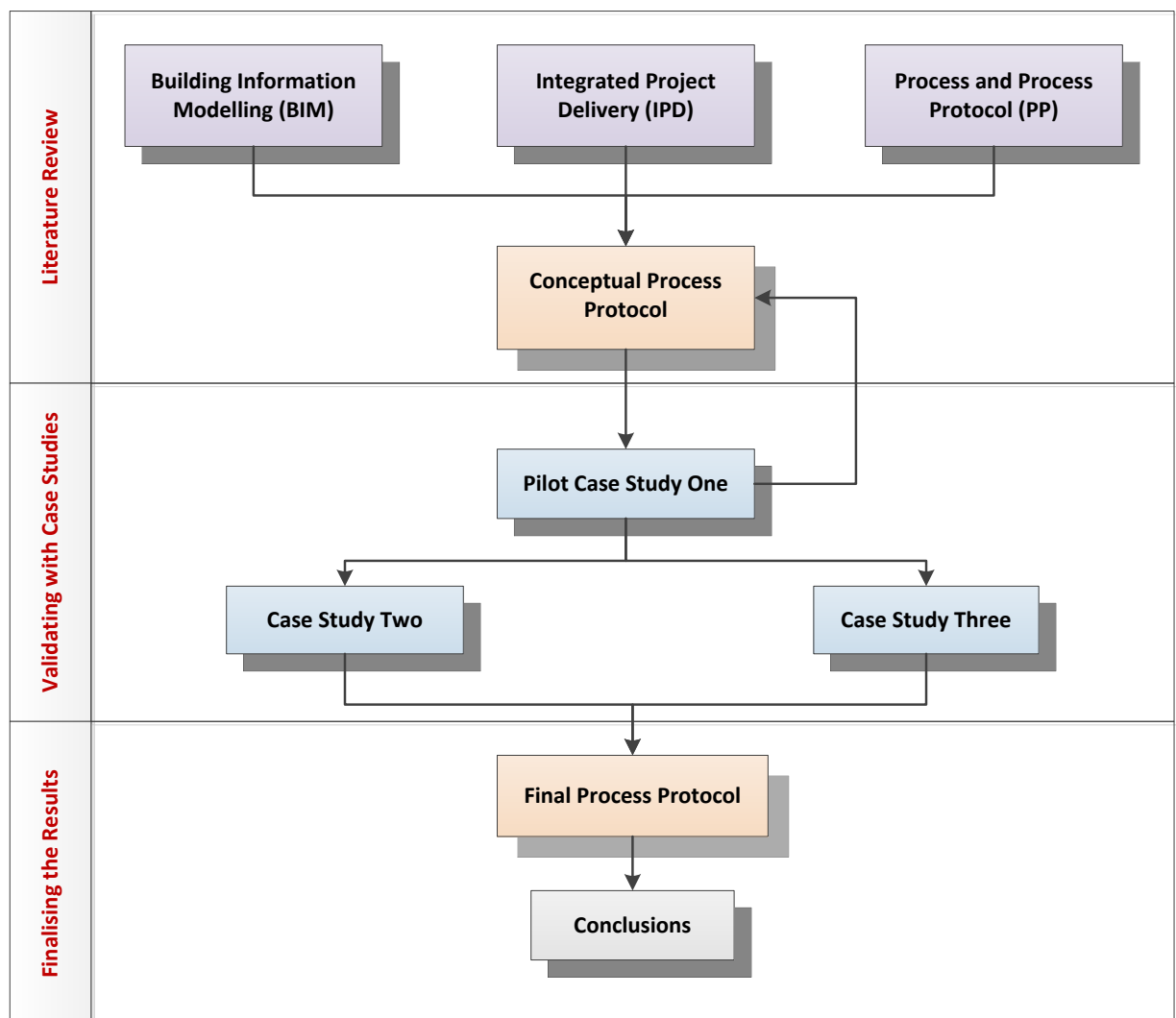


Figure 1.1: Research Framework

## **1.4 Research Design**

The general outline of the research method is shown in Figure 1.1 where the research activities are grouped into three phases:

1. A comprehensive literature review was conducted with specific focus on BIM and its implementation, collaborative environment and Integrated Project Delivery (IPD), as well as processes including process modelling and process protocol (PP). The principles of the University of Salford's process protocol were adopted as a baseline for this study because of its relevance. Through this review, a conceptual process protocol was drafted and proposed.
2. The proposed conceptual process protocol was then validated with a number of case studies. Semi-structured interviews were conducted with the client, consultants and contractors. A pilot case study (case study one) was carried out to validate the initial conceptual process protocols against the UAE local culture and contract conditions. The findings of case study one were fed-back into the conceptual process protocol to "localize" it while case study two and three were used to validate its various phases and processes.
3. Cross-discussion and analysis of the cases were then carried out to produce the final process protocol. Finally, conclusions were drawn and recommendations for future research were outlined.

## **1.5 Research Limitation**

The main aim of this research is to create a process roadmap with high-level processes to provide guidance to client organisations on how to implement and manage BIM/IPD effectively within their organisations. However, the development of the process protocol is constrained to the following:

1. This study uses IPD to refer to all levels of collaboration that could occur between a numbers of parties involved in the construction project, i.e. not the full scale collaboration as defined by the AIA. This approach could help to

easily accommodate the proposed process protocol within client organisations and be able to deal with the various levels of collaboration.

2. The process protocol only presents high-level processes for the concerned departments within client organisations and/or external project stakeholders along the project phases where these processes are carried out.
3. The status of the projects used in case study two and three were at the completion stage of the detailed design. This is mainly due to the lack of projects that have adopted BIM or IPD from design to construction in the UAE. Hence, the validation of the strategic planning, construction and facility management phases of the process protocol were based on the literature review and practical experience of the researcher and interviewees.
4. The interviewees of case study two and three have developed their BIM and collaboration experience from these two projects. They have no previous experience of wide scale BIM implementation or collaboration. This is mainly due to the low BIM uptake within the design and construction business.
5. There was no contractor involvement in case study three due to the late appointment of the preferred contractor by the time the case study was conducted. Therefore, their involvement in case study three was limited.

## **1.6 A Guide to the Thesis**

This thesis is divided into nine chapters. This chapter has identified the fragmented nature of the industry and stressed the needs for a collaborative environment using BIM as a vehicle to improve the performance of the industry. Special emphasis was placed on client organisations to drive the success of BIM/IPD implementation, which highlighted the need for a structured process approach to effectively manage BIM based projects. The remaining chapters are organised as follows:

Chapter 2 highlights the challenges facing the construction industry including fragmentation issues, wastage, environmental impacts and the increasing demand of clients for better value on their investments. The impacts of advanced technology and

new procurement methods are also addressed.

Chapter 3 emphasises the importance of managing project information using advanced technology, BIM and IPD. The issues and barriers of implementing BIM and IPD and the need for tools and mechanisms which can transfer client organisations to BIM/IPD-based ones are discussed.

Chapter 4 discusses how and why business processes need to be modeled. A structure way to implement business processes is proposed using project phases guided through the Royal Institute of British Architects's (RIBA) plan of work. A thorough investigation of the generic design and construction process protocol developed at the University of Salford, UK, are discussed and examined.

Chapter 5 discusses the research methodology used for this research. It addresses the qualitative and quantitative approaches along with their strengths and weaknesses. Case study as a research strategy is discussed and justified for this research whereby data is collected through semi-structured interviews.

Chapter 6 presents the initial proposed process protocol which has been thoroughly developed through literature reviews. All proposed phases are explained in detail including all actions before the phase, during the phase, deliverables, goals and gate status at the end of each phase.

Chapter 7 discusses the three case studies which involve three typical high-rise building projects (residential and commercial) in the UAE. Case study one is used as a "control case" to validate the initial process protocol against the local conditions and contracts. Nine important criteria that underpin the main process protocol have been derived and used to guide the data collection for the validation of the process protocol in case study two and three. Several semi-structured face-to-face interviews have been conducted and the findings show that all nine criteria are important for validation of the process protocol.

Chapter 8 discusses the findings of the case studies. The objective of elaborating the key findings for all case studies is to improve and validate the various components of the proposed process protocol. Detailed analysis has been conducted to back-track the main outcomes of the cases studies to the process protocol. Finally, a

recommended process protocol is presented with final improvements, which are backed up by the literature as well as practical supports and experiences.

Chapter 9 presents the summaries and conclusions of the research together with recommendations for future work.

## CHAPTER 2

# The Performance of the Construction Industry – Background

### 2.1 Introduction

Much of the waste that is generated throughout the life-cycle of a building is mainly related to project stakeholders not having access to information that others have created (Hecht, 2008). This results in waste and high costs. Waste can emerge for a number of reason including: change order requests during construction, engineering errors, the manual re-entry of data, redundant data collection, unnecessary meetings, mistakes in component dimensions or quantities and over design to allow for uncertainty.

Constructing Excellence, in 2009, undertook a comprehensive review, ten years after the Egan's report to determine the level of its impact on the industry and to outline the improvement agenda for the forthcoming decades. It found that after ten years, changes in the performance of the industry were evident but that these fell short of meeting the targets set out by Sir Egan. The Report entitled "*Never Waste A Good Crisis*" has been published based on the input of over a thousand industry professionals who completed online questionnaires, in depth interviews figures and key performance indicators from over 500 demonstration projects (Wolstenholme *et al.*, 2009). The overall findings were as follows:-

1. "Whilst the industry is moving in the right direction, it has fallen well shorts of Egan's targets. Both safety and profitability have taken reasonable steps forward, but progress on all other areas has been disappointing with an annual improvement of less than 3 percent".
2. The main obstacles to further improvements were business models that are based on short-term cycles, a fragmented industry, poor integration in the

supply chain, and a lack of strategic commitment at senior management and government levels.

The true cost of lacking interoperability in the UK could not be accurately measured. However, the estimates suggest that the scale of waste due to a lack of shared structured information for owner operators in the UK amounts to the financial loss of £100 million a year (BSI, 2010).

In addition to the above, the industry is facing a number of challenges at the macro level (Alshaw and Ingirige, 2002):

1. Increasing globalisation which give clients, consultants and contractors alike the opportunity to select products and services from around the world.
2. The availability of a variety of procurement methods which can re-define the roles and responsibilities of project participants in the interest of the project/client.
3. Clients are demanding better value for their investments and projects are becoming more complex than ever before. They are expected to be delivered on time and at a higher quality whilst at a low cost.
4. The long-term economic downturn has significantly affected the industry.

In 2011, the UK Cabinet Office through the Government Construction Strategy reiterated the ideas of Latham and Egan to drive for a more efficient industry and gave recommendations on two key variables: whole life cost and carbon performance which could advance a revolution in the construction industry in a time of economic melt-down. This suggestion has been recommended to the UK government to propose the mandatory use of BIM by 2016 (BIM Industry Working Group, 2011).

This chapter addresses the challenges that affect the future of the construction industry. Furthermore, the impact of environmental factors, which have led clients to raise their demands and increased the need for new procurement systems. This chapter also highlights the need for embracing new technologies, which could enhance the communication and integration in the construction industry, in order to improve the industry's performance.



## 2.2 The Economic Downturn and Client Demands

The global economic outlook remains highly uncertain. Recently, the Global Competitiveness Report 2012–2013 (Sala-i-Martin *et al.*, 2012) reported that the world economy is once again fragile and that global growth remains slow whilst recovery is weak. Grant Thornton's International Business Report (Thornton, 2013) shows that growth rates in and around Europe look set to disappoint over the next 12 months. Having contracted by 0.4 percent in 2012, the Euro-zone is expected to expand by just 0.2 percent in 2013. China is the only exception, where growth rates are expected to increase from 7.8 percent in 2012 to 8.2 percent in 2013. Whereas in the United States (US) economic growth is also still weak whilst unemployment remains high. Over the next few years, the construction industry, on worldwide scale, faces a tough challenge. Indeed the macroeconomic environment and consumer trends are having a deep impact on the construction industry.

With the global economy likely to remain volatile over the next couple of years, clients will be operating in an increasingly challenging marketplace. For many years the industry's main clients have experience problems, such as inconsistent quality and value for money. The National Audit Offices report 'Modernising Construction' (Bourn, 2001) stated that more than 70 percent of all publicly procured projects were over time or over budget. A research study conducted by Building Cost Information Service (BCIS) UK in 2006 found that nearly 40 percent of all projects that were studied had overrun the contract period. Clients are not prepared to pay for projects with extended contracts despite clear evidence that longer planning periods enable better risk assessments, reduce health and safety incidents and, improve quality as well as delivery costs and time (Rethinking Construction, 2002).

On the other hand, clients see the industry as overly complicated because of its numerous professions and organisations along with its convoluted processes and procedures of operation (Egan, 1998; Latham, 1994). In this regard, clients need to change their attitudes and gain a better understanding of their role as the "construction client". The construction client represents both owners and end users who are responsible for ensuring that all the requirements of owners, customers and

wider society are met by a construction project, from its initial conception to the final implementation (Vennström, 2008).

Egan (1998) presented the need for benchmarks as a method of implementing improvements and stated for reductions in cost, time and defects. Moreover he argued for the measurement of key performance indicators to become the drivers of change. He also recognised that client leadership was critical and that the notion of a best practice client needs to be established. A publication by the National Improvement and Efficiency Partnership (NIEP) (2012) suggested that client leadership in local government should be informed by six principles that will help deliver quality and efficiency. These principles are as follows:

- i. *Taking a whole-life view of value* – life-cycle costing at an early stage of a project or program helps in testing options, assessing long-term affordability, balancing capital and running costs as well as, ultimately, providing instructions for how a building in use should be occupied;
- ii. *Using framework agreements* – collaborative agreements need to be setup and make procurement of individual projects more cost effective and quality-led;
- iii. *Innovation in supplier relationships* – focusing on innovation and the best-performing materials and techniques over the longer term. Collaboration and sharing information serves the whole-life approach to components and products;
- iv. *Leading on good design* – delivering value for money and quality is about making the right connections between design decisions and the costs of both construction and maintaining a building in use;
- v. *Commitment to sustainable development* – clients need to apply environmental sustainability considerations to strategic decisions on issues like site selection and procurement, rather than to the detail of building services, materials and interior design; and
- vi. *Considering building management at an early stage* – knowing how a building is going to be used is an essential part of securing long-term value which will enhances the prospects for the sustainable use of a property.

At the earliest stage, the client should identify and engage with stakeholders who are directly or in-directly involved in a project. Building an in-house or cross-organisational team to manage a programme or project is the key to successful collaboration. The NIEP (2012) proposed that one responsibility of client leadership should be the ability to recognise the range of skills already available within and between organisations. As well as to determine what is required for the task and whether any additional training might be offered to the individuals concerned.

## **2.3 The Impact of Environmental Factors**

The issue of the environment has been a major topic and research subject since the mid-eighties. The construction of buildings and infrastructure on the other hand, affects the environment, in terms of resource consumption, pollution and waste production. The amount and type of such affects depends on many factors, such as the stage of construction, type of construction work, direct and indirect stakeholders' design change contribution and practices throughout the project lifecycle.

A briefing note published by the Willmott Dixon Group (Willmott Dixon, 2010) on the impact of construction and the built environment shows that the construction industry uses almost 45-50 percent of energy, 50 percent of water and 60 percent of raw materials. On the same note, it stated that the industry contributes to 23 percent of air pollution, 50 percent of climate change gases, 40 percent of drinking water pollution and another 50 percent of landfill waste.

Construction waste is normally related to design changes, leftover material scraps, the wastage of no-recyclable/re-useable packaging, design/detailing errors and poor weather (Faniran and Caban, 1998). Furthermore, Osmani *et al.* (2006) performed a study of the attitudes of architects and contractors towards the origins of construction waste and the result indicates that construction waste is related to design, site operation, procurement routes, material handling and sub-contractor's practices. Later, Osmani *et al.* (2008) compiled and grouped the main sources of waste factors in terms of construction lifecycle stages. These stages include the contractual, design, procurement, transportation, on-site management and planning, material storage, material handling, site operation, residual and others.

The construction industry will not only have to face issues presented by the economic crisis but will also have to fight the challenges created by global warming. Such challenges may necessitate changes in construction practice. Sustainable construction procedures, which use new materials and technologies, have been proposed by experts. These can reduce energy consumption and operation and maintenance costs, by reference to better work environments and other green building benefits. A recent study by Greg Kats for the Massachusetts Technology Collaborative (Kats, 2003) on green building costs and financial benefits, found that although there is an additional 2 percent cost on the materials, the overall saving on operating and maintenance costs for the entire cycle of the building can be reduced by 20 percent.

The European Construction Technology Platform on the strategy for sustainable competitiveness of the construction sector (ECTP, 2012) highlighted that fighting climate change and smart buildings are key points to achieving a resource-efficient and sustainable construction sector. ECTP has also restated that the lowest initial cost based approach is completely wrong and that the approaches of Life Cycle Analysis and Life Cycle Cost Analysis should be incorporated into the planning, design and construction of projects. Achieving these targets requires new knowledge and skills, at all stages of design and construction.

## **2.4 The Impact of Advanced Technology**

The construction industry is facing a significant challenge of inaccurate and untimely communications amongst project stakeholders, inevitably resulting in costly delays to construction projects. Most of the information is often “lost” in the sense that it is not retained in order to be shared with partners, which creates the need for it to be re-entered. This causes a major problem with maintaining up-to-date versions of the information. Over the past decade, advances in IT have introduced improvement in managing information and enhance the ability of organisation to restore, retrieve and reuse information.

Construct IT (2008) conducted a survey which aimed to capture the current practices and thinking of Chief Executives and IT Directors, within the industry, related to IT investments and its impact on the industry’s performance. The top 100 companies

(both consultants and contractors) were surveyed. The results clearly showed that construction organisations acknowledge the strategic nature and significance contribution of IT in an organisational-wide scope. IT strategies are gradually being integrated into organisational business strategies and the impact of technology is recognised for delivering competitive advantages for the future. On the other hand, construction organisations have had their IT investments influenced by a state of readiness of the organisation to successfully receive new and future IT investments (Construct IT, 2008). The survey found that:

1. The importance of aligning IT investment to business process management is highly recognised but is not yet being practiced.
2. Industry recognises the need for IT skills and competences within organisations, but has not yet utilised them for innovation.
3. Industry strongly believes in investigating new technologies for competitive advantage but has not yet taken pursued this.

The most critical finding of this survey was that a significant gap exists between “what is necessary” to achieve IT-based improvements, and “how to implement change”. This clearly shows that the mechanism (processes) to by which to realise IT benefits and maximise success are not yet fully understood.

In this context a “technology push” alone, will not harness the full business potential of IT. It is the innovation in process improvement and management, along with IT as an enabler, which is the only mechanism to ensure sustainable growth and improvement. This requires an organisation to be in a state of readiness so that it can positively absorb IT enabled processes into its working practices (Alshaw, 2007). In addition, the competencies that an organisation needs to develop in order to acquire the capability to strategically benefit from IT, prior to IT investment, falls under four main parts: people, processes, the work environment and IT infrastructure (Alshaw, 2007). The first two elements are the key to change and improvement while the latter two parts are enablers without which the first two elements cannot be sustained.

## **2.5 The Impact of New Procurement Methods**

Client interaction with the industry requires engagement with a diverse group of professionals and businesses and entering into contracts with them. This process is normally called 'procurement'. Boyd and Chinyio (2008) defined procurement as the framework within which construction is brought about, acquired or obtained. In the traditional form of procurement, the client decides what is wanted then appoints and briefs a designer (architect or engineer), who designs the building and informs the selection of a contractor and the contractor then delivers what has been designed.

The construction strategy (CabinetOffice, 2011) sets out the principles of an alternative procurement approach. This is designed to eliminate the wastefulness of teams completing and costing a series of alternative designs for a single project, only one of which will be built. Good procurement practice is crucial to reduce the overall cost of projects, to improve the economic efficiency of the construction industry and to ensure that projects, when complete, are fit for purpose, thereby securing whole life value. The Cabinet Office (2011) recognised that the right model for public sector construction procurement in the UK is one in which there is an alignment of interests between those who design and construct a facility and those who subsequently occupy and manage it.

The choices and variations of delivery methods have increased considerably over the last two decades. There are a few types of procurement systems: from traditional methods, like design-bid-build and design-build, to more integrated methods, such as partnering and Integrated Project Delivery (IPD). These will be described briefly in the following sections.

### **2.5.1 Design-Bid-Build (DBB)**

The main characteristic of this procurement system is the separation of responsibility in design and construction, which are handled by two different organisations. In this method, the client first hires the architect or engineer to design the building or structure using a low price or low bid method. The design professional prepares a

design, moving through the three standard design phases: schematic design, design development and finally contract documents.

A key advantage of DBB is that it allows flexibility during construction when variations to designs and specifications of work can be accommodated. DBB is favoured by architects and engineers as it allows them to work as technical managers and set project specifications for everyone to follow.

The key disadvantage of DBB is that contractors are not involved in the initial design phase where the ability to influence the project's cost and quality is significantly constrained. The clients are liable for any errors and emissions in the plans and specifications. Moreover the contractors have to put in extra contingency money for those unforeseen conditions like design changes, late project deliveries and legal costs.

### **2.5.2 Design-Build (DB)**

Unlike DBB, the DB approach is made with only one single entity, i.e. the main contractor. The responsibility of the project is usually in the hands of the contractor, who includes a team of architects and engineers to manage the design. DB-contractors are responsible for delivering the right product at the right time to clients.

The advantage of DB is that the client resigns from any direct design involvement going into a DB contract, leaving the detailing of the project in the hands of the DB contractor. The contractor is free to interpret within the specifications of the design requirements. Hence, there is little flexibility for the client to make changes after the initial design is approved and a contract amount is established. The building is typically completed faster, with far fewer legal complications and at a somewhat reduced total cost.

The disadvantage of DB is that it gives less design control and involvement to the client and stakeholders. Tendering is more expensive so it carries more risks for the contractor than the traditional approach.

### 2.5.3 Partnering

Partnering is a structured management approach to facilitate collaboration across contractual boundaries, which includes the concepts of teamwork, between the supplier and client, and of total continuous improvement (Construction Industry Board, 1997). It requires openness between the parties, ready acceptance of new ideas, trust and perceived mutual benefit. Partnering promotes improved performance through collective business relationships based on best value rather than lowest cost.

W. C. Ronco and J. S. Ronco (Merritt, 1996) have identified nine different situations in which partnering is suitable, such as those involving large client organisations, multiple clients and/or the government. For complex projects and those designed with the application of new technologies, partnering can help provide the strategies and skills to strengthen the communications necessary for effective problems-solving and information sharing among the firms involved with the project.

Constructing Excellence (2004) highlights the following elements for the set up of a partnering arrangement:

#### 1) *Commitment*

Commitment from the highest level must exist which is continuously communicated and reinforced throughout the organisation. Issues of cultural change are relevant and it is crucial to seek and achieve input from all those involved.

#### 2) *Self-assessment*

Organisations need to understand their own readiness and determine what and why they need a partner, the capabilities and right skills and a will to move towards a new working culture.

#### 3) *Selection*

Trust is a critical factor in partnering. The most significant proportion of partnering arrangements are made by companies that already have developed good working relationships. However, in order to select the right partner, some attributes need to be determined such as understanding the partner, previous



partnering experience, environmental policy, management style, customer care and resources.

#### *4) Mutual Objectives*

A clearly defined objective must be established that meets the aims of each of the parties in order to achieve a successful partnering.

#### *5) Problem Resolution*

A joint problem resolution mechanism needs to be established to enable decisions to be taken quickly and effectively. Thus, prevent minor problems from developing into damaging disputes, etc.

#### *6) Continuous Improvement*

Relevant indicators must be determined and performance needs to be measured to demonstrate improvement using some key performance indicators (KPIs). A continuous cycle of “measure, review, identify and implement” is required.

#### *7) Contractual Information*

Contracts have normal consist of a partnering agreement in conjunction with an appropriate amended standard form of contract. The partnering agreement generally defines the provisions of the arrangement such as attitude, partnering performance, allocation of risk and incentives for reward or penalty.

#### *8) Risk and Reward Issues*

Risks that might be encountered should be jointly identified and assessed and should be allocated to the relevant parties. Some arrangement could also be made on cost-reimbursement and profits where the incentives are generally built into the agreement to reward good performance or penalise poor performance against agreed targets which relate to costs, time, KPIs, etc.

#### **2.5.4 Public Private Partnerships (PPP)**

Public Private Partnership (PPP) is a key element in government strategies for delivering modern, high quality public services and promoting competitiveness. They cover a range of business structures and partnership arrangements, from joint ventures and concessions to outsourcing, and the sale of equity stakes in state-owned businesses (The Stationery Office, 2000). In a PPP arrangement, the government remains actively involved throughout the project's life cycle. The private sector is responsible for commercial functions such as project design, construction, finance and operations (partnerships British Columbia, 2003).

A key advantage of PPP is that it increases project quality compared to traditional construction agreements. It has a shared risk in the project like in partnering. The facility is owned by the investor, which means that the private sector is responsible for the construction and maintenance of the building. Investors, operators and general contractors have a long distance perspective in mind when designing and constructing the building; cost effective solutions in this matter, are essential to the total profit of the project (Grimsey and Lewis, 2004).

The key disadvantage of PP is that clients may experience higher total lifecycle costs. The proposal process can be very expensive for all involved and a high level of expertise is required to execute a PPP project.

In spite of the existence of all these types of contracts, construction projects are still facing significant delays and cutover. Apart from Partnering, collaboration between stakeholders is minimal, if any. So, there is a need to have a work environment where collaboration is encouraged among all stakeholders and to enable them to focus on achieving one goal: the efficient delivery of the project.

### **2.6 Industry Performance and the Need for Improvement**

Construction projects' performances need to be measured to ensure the planned improvements in terms of cost, time and quality are achieved in comparison to similar projects. Constructing Excellence produced the Construction Industry Key Performance Indicators (KPIs) in 2011. These revealed that 55 percent of current

projects are delivered late and 37 percent are not delivered to the intended budget. In 2012, similar studies have been conducted and have indicated that the construction industry has endured a sharp fall in profitability over the previous year as workloads have fallen and margins have been squeezed (Constructing Excellence, 2012). Despite this challenging economic environment, previous improvements in client satisfaction have been sustained and the predictability of project delivery, both to cost and to budget, has improved further.

A study of labour productivity conducted by the Center for Integrated Facility Engineering (Teicholz, 2004) revealed that for the years 1964-2008 many industries have seen dramatic productivity improvements. However, the productivity in the construction industry over the same period has steadily declined as shown in Figure 2.1. There is a lack of productivity statistics available other than that produced in the US and that these indicators are used as a guide to show the slow performance of the construction industry around the world.

Most of the productivity improvements in other industries have been attributed to the use of information technology and a rethinking of the processes (Drucker, 1999). An example of this is the application of the lean manufacturing processes in the automobile industry.

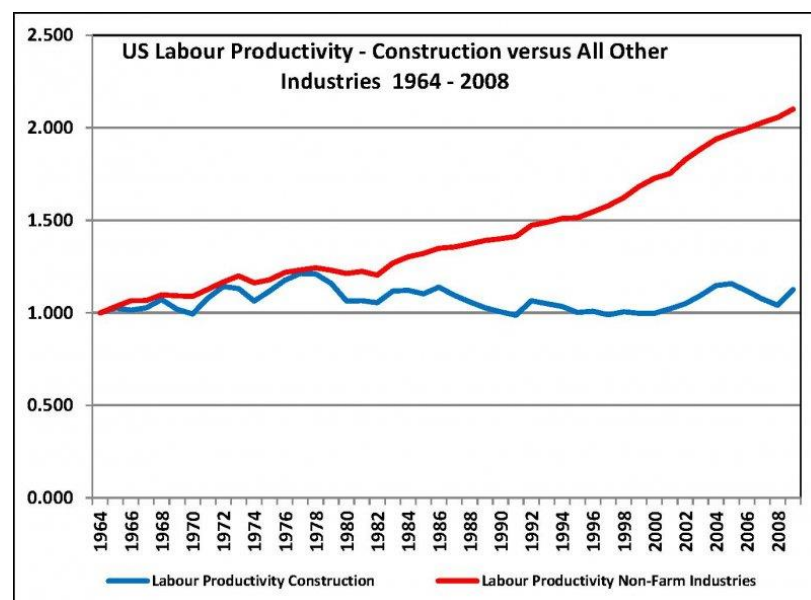


Figure 2.1: Labour Productivity in Construction and Non-Farm Industries (Teicholz, 2004)

The UK Strategic Forum was subsequently formed in 2001 to oversee the industry reform movement. This resulted in a revised set of targets for achieving industry reform by the end of 2007 (Egan, 2002). The time horizon has been extended through to 2012 and current emphasis is given to the 2012 construction commitments which seek to promote enlightened practices on the back of the construction works relating to the London 2012 Olympic Games.

Nowadays, the major focus for most of the research initiatives in the construction industry is on finding and replicating a better solution for an integrated approach and process that similarly helps make dramatic productivity improvements in other industries.

## **2.7 The Main Challenges Facing the Industry**

The fragmented nature of the construction industry has been cited, throughout the literature, as a primary factor that affects its overall performance and productivity. Any construction project involves many stakeholders, including architects, engineers, contractors, subcontractors and suppliers to deliver a one-of-a-kind project, which requires a tremendous amount of coordination. This involves the collaboration of a number of organisations which are brought together for the duration of the project to form the “project team”. These organisations vary in terms of size, capabilities, skills, practices, IT systems, etc. and more often they are based in different locations but need to work collaboratively and share the same project information. This imposes a great challenge in meeting projects’ objectives of time, cost and quality and most importantly meeting client requirements through better collaboration between the project stakeholders.

Successive independent reviews of construction in the UK have emphasised the need to improve the culture, attitudes and working practices which have existed in the industry for a long time. Many reviewers (Egan, 1998; Latham, 1994; Levene *et al.*, 1995) have identified the need for a number of fundamental changes in the way construction services are procured and delivered to improve value for money in aspects of the construction process. The Modernising Construction (2001) report has

identified the factors that need to be considered in order to improve the performance of the construction industry as follow:

- Much more consideration of end users in the design and construction of buildings, including future needs. If flexibility is required it must be assessed as part of the value for money evaluation of options and taken into account in designs.
- Better integration of the various stages in the construction process - design, planning, construction and completion to remove waste and inefficiency.
- Partnering between clients, contractors and consultants to resolve problems collaboratively, reduce project slippage and cost overruns, promote innovation and improve quality.
- Longer term relationships between clients and contractors to promote continuous improvement in the cost and quality of final products.
- Recognition that accepting the lowest tender price for the initial capital costs does not give value for money and more consideration needs to be given to the costs of a building over its whole life.
- Move away from adversarial approaches between the industry and clients which have produced high levels of litigation.
- Greater use of prefabrication and standardised building components in construction to improve quality and cost effectiveness.

The use of new types of collaborative environment procurement systems and the use of digital project information by stakeholders throughout the project lifecycle have started to be demanded by the clients who realise the potential benefits of such procedures. Another beneficial factor is client's leadership is whereby clients need to take a leading role in creating a collaborative environment where project stakeholders can share experiences and exchange project information in the interests of the project.

## 2.8 Summary

The construction industry has been repeatedly labelled as inefficient due to rework and wastage either through materials or data used. Information is often “lost” in the sense that it is not retained to be shared by partners, which creates the need for it to be re-entered thus creating a major problem on maintaining up-to-date version of information. The main reason behind the unavailability and ill utilisation of project information is the fragmented nature of the industry. Indeed it involves many parties, which requires tremendous amounts of coordination and collaboration.

Recent studies prove that many projects were overdue and above budget and that clients started demanding more value by improving the quality, delivery cost and time. Performance improvements can be achieved through the implementation of a collaborative environment and the use of digital project information. In this context, clients should not only participate but should drive the collaboration process by leading the project at the early stage. This chapter has highlighted the main challenges facing the industry, i.e. to bring together a number of organisations to form the “project team”, work collaboratively and to share project information. This requires improvements in working cultures, attitudes and practices which have existed in the industry for years.

## **CHAPTER 3**

# **Building Information Modelling (BIM) and Integrated Project Delivery (IPD)**

### **3.1 Introduction**

In May 2011, the UK Government Construction Strategy (GSC) was formulated with the aim of reducing the cost of government construction projects by 15 to 20 percent by 2015 (CabinetOffice, 2011). With this strategy, it means that the public sector will become a better client - more informed and better coordinated when its requirements are specified, designed and procured.

Over the past decade, however, there have been clear improvements in the performance of industry which have led to an increase in productivity, efficiency, infrastructure value, quality and sustainability. Whilst at the same time these improvements have helped to reduce life cycle costs, lead times and duplications. The main attributor to these improvements is the effective collaboration and communication among project stakeholders, which has been brought about through more effective procurement approaches such as partnering and design and build. Most recently, there is a focus on creating and reusing digital project information of stakeholders throughout the life cycle to facilitate the exchange of information among partners. This shift is based around BIM (Building Information Modelling) and collaborative environment.

This chapter will highlights the importance of managing the project information and the use of current technology, i.e. BIM and, the project delivery process, IPD. BIM and IPD go together and represent a clear diversification from the current linear processes that are based on paper-based exchanges of information.

### 3.2 The Management of Project Information

Larges amount of project information are generated and used during the various stages of a project's lifecycle. Sharing and maintaining this information among multiple disciplines is a complex and difficult task (Ito *et al.*, 1990). Most of the information used in a construction project originates in the design process (Crotty, 2011).

The entire building and design process is characterized by high levels of fragmentation. There are multiple stakeholders involved, as shown in the Figure 3.1, including Architects, Engineers, contractors and clients. The complex information flow and multiple modes of communication that are possible make effective communication and co-ordination key challenges. Project communications extensively rely on paper-based, document centric, communication models.

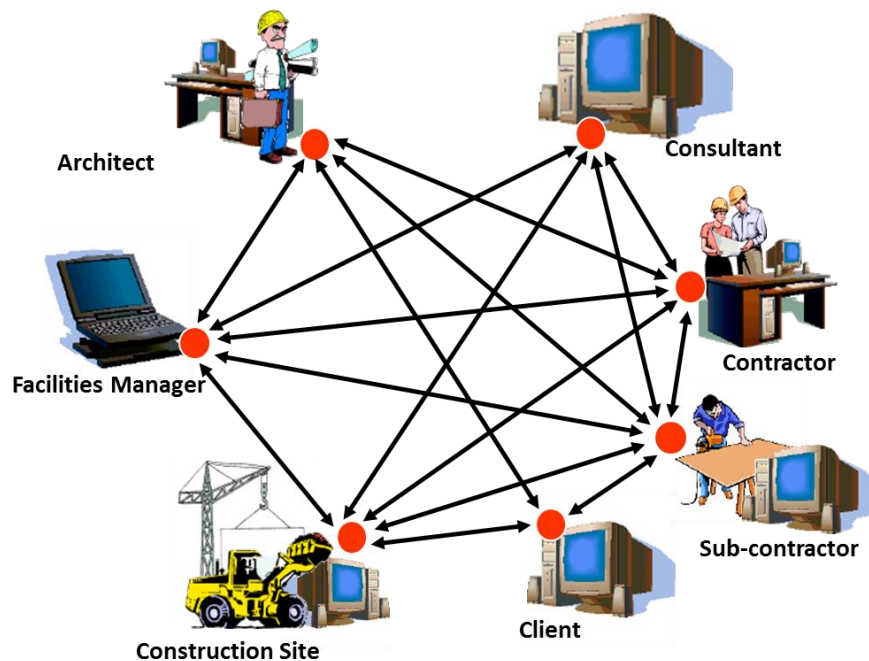


Figure 3.1: The Prevailing Document Centric Communication Model

Conventionally, a good deal of design and construction work is document-based. Information is communicated and stored via a variety of drawings and reports that, despite being stored and distributed in digital form, are essentially 'unstructured' and thus of limited use (Langdon, 2012b). Not only is this information unstructured, it is also held in a variety of forms and locations that are not formally coordinated (information on individual building components, for example, are contained on



drawings, specifications, bills of quantity, etc.). Such an approach has considerable potential for data conflicts and redundancy as well as risks to data integrity and security.

There are challenges with the quality of the information being generated and used on the project and with the means by which this information is communicated and shared amongst the project team. Such flow of information needs to be managed so that it will be received or accessed when required. Information management is not for handling drawing issues only, but if it is correctly administered, it can provide the necessary framework whereby all involved individuals are aware of their responsibilities and how to carry them out (Atkin and Maunsell, 1990).

Conversely, by providing an intelligent, digital structure for project information and ultimately a means by which information can be held centrally as a 'single' model – BIM opens up a wide range of possibilities for improvement (Langdon, 2012b). These include better ways of generating, exchanging, storing and reusing project information that greatly improves communication between different design and construction disciplines through the life of the asset.

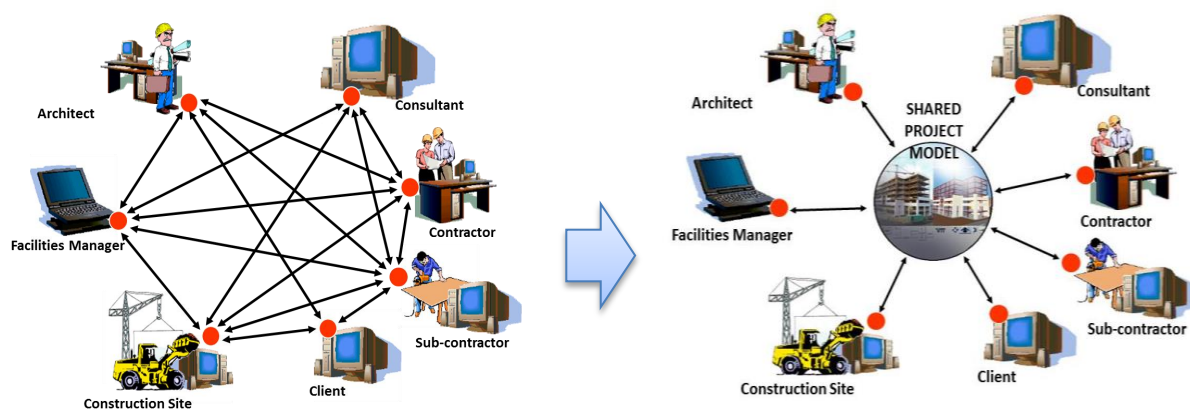


Figure 3.2: Transforming Document Centric Model to Shared Project Model

Managing project information efficiently by making it freely available to all project stakeholders will achieve a high level of integration. BIM was conceived to remedy such problems by providing a model based mechanism to manage all building related information in a particular project in a shared repository that could be accessed by all project participants and readily incorporated into project documents (Figure 3.2).

BIM provides the construction industry with a virtual prototyping tool to test and simulate the design before production. Likewise, by using a shared project model, information can flow both upstream and downstream, enabling more concurrent ways of working during project design, execution and during later phases of the project lifecycle (Aziz, 2011).

BIM intends to foster optimal collaborations between project stakeholders through the life-cycle of a facility to insert, extract, update or modify information. BIM has the potential to bring project stakeholders closer together and thus ultimately ensuring a more accurate and multi-disciplinary collaboration (Thomassen, 2011). BIM can therefore be seen as a new and modern development process for the integration and utilisation of today's software options. In addition, researchers have identified that understanding and developing integrated work practices is important in order to efficiently utilise BIM (Harty, 2005; Moum *et al.*, 2009; Taylor, 2007; Taylor and Bernstein, 2009).

The following sections will give further details on BIM and IPD.

### **3.3 Building Information Modelling (BIM)**

Much of the waste that is generated throughout the lifecycle of a building is mainly related to project stakeholders not having access to information that others have created (Hecht, 2008). This results in waste and high costs, whether the waste comes from change order requests during construction, engineering errors, the manual re-entry of data, redundant data collection, unnecessary meetings, mistakes in component dimensions or quantities or over design to allow for uncertainty.

One reason for an increase in this adoption is that traditionally much project information and development relies substantially on human input, subsequent multiple manual checks and cross-referencing operations. On complicated projects, such actions inevitably lead to errors or missing information which in turn leads to extra cost and waste (Cohen, 2010). BIM, amongst other things, seeks to streamline processes, present construction information in an accessible and common way, minimise the possibility of missing or clashing information and ensure optimised project coordination.

BIM is a collaborative way of working, underpinned by digital technologies that unlock more efficient methods of designing, creating and maintaining assets. BIM embeds key product and asset data and a 3 dimensional computer model that can be used for effective management of information throughout a project's lifecycle – from concept through to operation (HM Government 2012).

### **3.3.1 Definition and Role of BIM**

BIM is essentially a new way of designing buildings and managing the design and construction processes that have been made possible by advances in computer-based modelling technologies. In sum, BIM exploits the potential of computer-based modelling technologies to provide a new way of designing buildings and managing the design and construction processes (Langdon, 2012a). It is a digital representation of project information, which can be easily and quickly stored, accessed and shared by all project partners. BIM can also be considered as a component-based 3D representation of buildings within which the properties and behaviours of each element are attached. The overall aim of BIM is to provide a common database and intelligent information that can be used seamlessly and sequentially by all members of the design and construction team and, ultimately, by the client or operator of a facility throughout its life-cycle (Holness, 2006). It can also be extracted and analysed to generate information that can be used to make decisions and to improve the process of delivering the facility (AGC, 2005).

It provides a major step-change in the ability of design and construction teams to structure and exchange information around shared, computer-based models of a building project. This of course can bring great benefits, including better design coordination as well as reductions in design costs and improved communication throughout the design and construction processes.

The “low hanging fruit” advantage of BIM models is to produce a coordinated and clash free design along with its potential of visualising building information in 3D. The latter is the best intuitive method for effective communication and collaboration amongst the project stakeholders, particularly the client. In simple terms, this means that the client's requirements can be captured and verified effectively, building designs

can be developed in a shorter time since a shared understanding can be established quickly and planning activities are performed more accurately. BIM models can be developed to produce a number of added value applications such as 4D simulations (3D + time) in order to conduct counterfactual analysis and 5D costing.

### **3.3.2 BIM Development in Design and Construction**

The focus on creating and reusing digital project information, throughout the life cycle to facilitate the exchange of information among project stakeholders, are based around ideas of BIM and collaborative environments.

BIM-based design solutions differ from their traditional counterparts in that:

- i. They are created and developed on digital databases which enable collaboration and effective data exchanges between different disciplines;
- ii. They allow change to be managed through these databases so that changes in one part of the database are reflected in (and coordinated through) changes in other parts; and
- iii. They capture and preserve information for re-use by all members of the design and construction team, including facilities' management (FM), and users' operations and management.

A building information model can be used for the following purposes (Azhar *et al.*, 2008):

- i. *Visualization*: 3D renderings can be easily generated in-house with little additional effort.
- ii. *Fabrication/shop drawings*: it is easy to generate shop drawings for various building systems. For example, A sheet metal ductwork shop drawing can be quickly produced once the model is complete.
- iii. *Code reviews*: fire departments and other officials may use these models for their review of building projects.
- iv. *Forensic analysis*: a building information model can easily be adapted to graphically illustrate potential failures, leaks, evacuation plans, etc.

- v. *Facilities management*: facilities management departments can use BIM for renovations, space planning and maintenance operations.
- vi. *Cost estimating*: BIM software has built-in cost estimating features. Material quantities are automatically extracted and changed when any changes are made in the model.
- vii. *Construction sequencing*: a building information model can be effectively used to create material ordering, fabrication and delivery schedules for all building components.
- viii. *Conflict, interference and collision detection*: As BIM models are created, to scale, in 3D space, all major systems can be visually checked for interferences. This process can verify that piping does not intersect with steel beams, ducts or walls.

In recent years there has been an explosion of interest in the development of BIM in construction industries around the globe (Hooper and Ekholm, 2010). The recent uptake of BIM is a sign of recognition, by international governments and industries of its abilities to enhance the design and construction process. The widespread deployment and use of BIM has been identified by the National Institute of Standards and Technology (NIST) in the U.S. as a vital way of advancing the efficiency, quality, timeliness, cost-effectiveness and sustainability of construction projects (Huang *et al.*, 2009).

Whilst the construction sector is generally still at an early stage in its deployment of BIM, awareness and use of this process are growing rapidly in a number of key markets, including the USA, UK, Europe and Australasia. BIM has received a significant boost of attention in the UK and USA through government mandates. BIM is already promoted by US Government agencies such as the General Services Administration (GSA), the U.S. Army Corps of Engineers, the United States Coast Guard, Department of Veterans Affairs and along with several State Governments. In Norway, the Government has adopted both BIM and building SMART as its preferred methodology for federal construction projects. There is also an agreement to use open BIM Standards between GSA and, the Danish Enterprise and Construction Authority (DECA) in Denmark Senaatti-Kiinteisist in Finland and Statsbygg in Norway. In the

Australasia region, BIM has been promoted by governments in Australia, Singapore, Hong Kong and South Korean.

Table 3.1: Example BIM Initiative Worldwide (Modified from BCA, 2011)

Country	BIM Initiative
United States	The General Services Administration (GSA) in the U.S.A. is a pioneer in advocating the adoption of BIM for public sector projects. It has also developed a suite of BIM guidelines.
United Kingdom	The BIM Industry Working Group in the U.K. has prepared a BIM strategy to increase BIM use over a five-year period by 2016.
Norway	The Norwegian government has stated its commitment to succeed in BIM adoption in 2010.
Denmark	Danish state clients such as the Palaces & Properties Agency, the Danish University Property Agency and the Defence Construction Service require BIM to be used for their projects.
Finland	Finland's state property services agency, Senate Properties, has required the use of BIM for its projects since 2007.
Hong Kong	Hong Kong's Housing Authority has set a target to apply BIM in all new projects by 2014. It has also developed a set of modeling standards and guidelines for effective model creation, management and communication among BIM users.
South Korea	South Korea's Public Procurement Service made BIM use compulsory for all projects over S\$50 million and for all public sector projects by 2016.
Singapore	The Building and Construction Authority (BCA) implemented the BIM Roadmap in 2010 with the aim that 80 percent of the construction industry will use BIM by 2015. This is part of the government's plan to improve the construction industry's productivity by up to 25 percent over the next decade.
Australia	The Australian Government set a date of 1 July 2016 from which procurement for all its buildings will require full collaborative BIM based on open standards for information exchange (commonly referred to as Open BIM).

Globally, many building and infrastructure projects are undertaken by the public sector. Thus the public sector can play an important role in leading the industry

towards BIM adoption. This opportunity has been pursued by numerous governments worldwide (See the summary in Table 3.1).

BIM has shown its potential for usage throughout the entire the construction industry starting, from pre-construction up to post construction. There is no surprise why the initiative of implementing BIM has been taken by the client. However, the advantages of BIM will be gained if a well-planned BIM Implementation Plan can be developed and implemented.

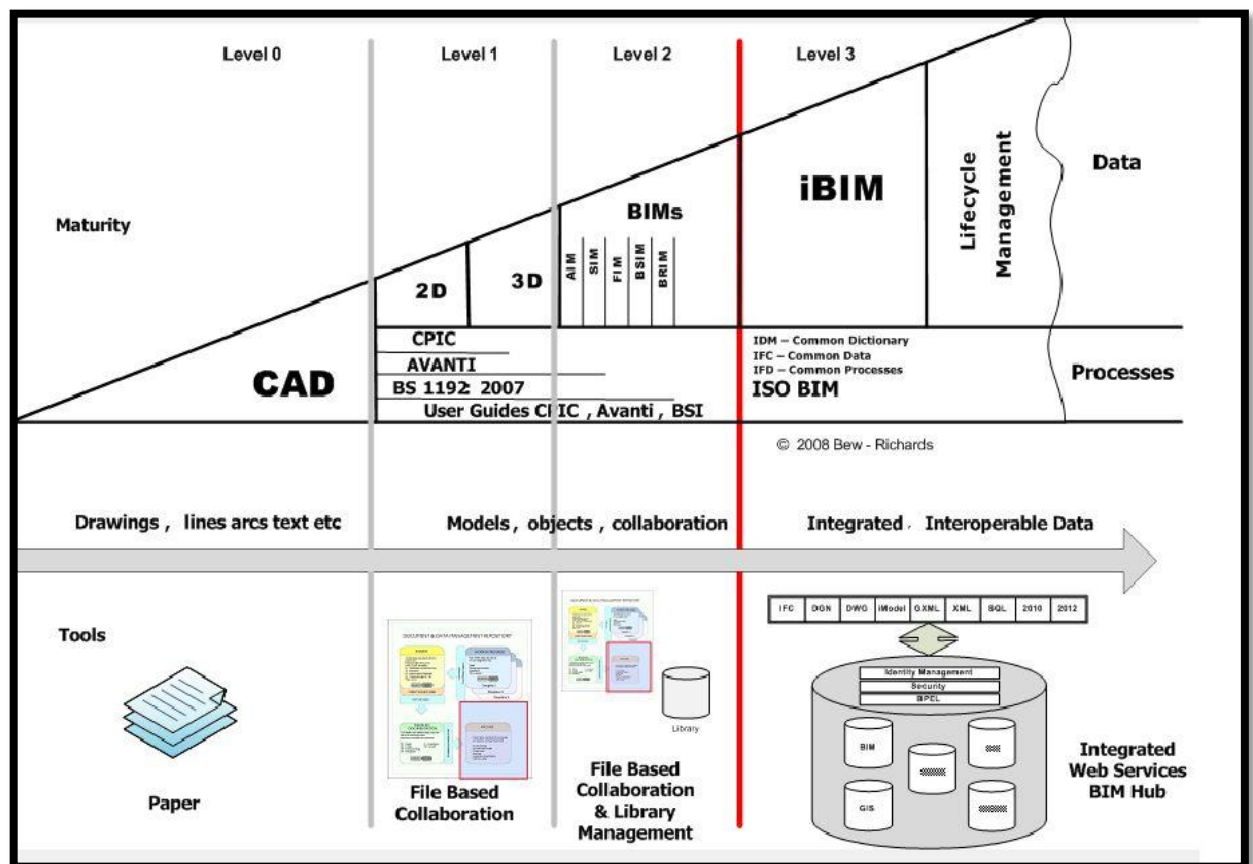


Figure 3.3: UK BIM Strategy Chart (BIM Industry Working Group, 2011)

### 3.3.3 UK BIM Strategy

The BIM Industry Working Group in the U.K. has prepared a BIM strategy to increase BIM use over a five-year period by 2016. Levels 0 to 3 have been proposed which categorise types of technical and collaborative working to enable a concise description and understanding of the processes, tools and techniques to be used (BIM Industry Working Group, 2011) as shown in Figure 3.3. These levels are:

0. Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely data exchange mechanism.
1. Managed CAD in 2D or 3D format using BS1192:2007 with a collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration.
2. Manages 3D environment held in separate discipline “BIM” tools with attached data. Commercial data managed by an ERP. Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as “pBIM” (proprietary). The approach may utilize 4D programme data and 5D cost elements as well as feed operational systems.
3. Fully open process and data integration enabled by “web services” compliant with the merging IFC/IPD standards, managed by a collaborative model server. Could be regarded as iBIM or integrated BIM potentially employing concurrent engineering processes.

The UK Government has setup an initiative which is focussed on achieving a “Level 2” adoption for all its projects by 2016.

### **3.3.4 BIM Implementation Plan**

AGC (2005, p. 24) stated that “each project is unique, and the implementation of BIM should be tailored to the needs of the project”. Therefore, standard implementation plans must be sensitive and can be tailored to the individual characteristics of each project.

Stebbins (2009) considered BIM as a process rather than a piece of software. He clearly identified BIM as a business decision and the method of implementing BIM as a management decision. BIM implementation is strongly related to managerial aspects of professional practices: most industries have different working styles and cultures.

Mactavish and Iqbal (2013) define the BIM Implementation Plan as the core co-ordinating tool that defines how BIM will be applied to a project. BIM Implementation Plan is not a BIM manual and should not include detailed processes for undertaking



different studies. Instead it is a vehicle for clearly stating the protocols that will be followed when undertaking the project.

A UK standard BIM Implementation Plan template does not currently exist, although examples are emerging. The need for its development and implementation on design projects has been emphasised by leading organisations, such as HM Government, RICS, CPIC (Construction Project Information Committee) and Constructing Excellence.

The BIM Implementation Plan should define all BIM-related aspects that will be applied to the project (including the objectives, activities, data and design protocols). These, typically comprising the following components (Mactavish and Iqbal, 2013):

- Executive summary
- Introduction
- Project Information
- Key Project Contacts
- Project Goals, BIM Uses and Capabilities
- Roles and Responsibilities
- BIM Process Design
- Model Element LoD and Responsibility Worksheet
- Facility and Asset Management Requirements
- Collaboration Procedures
- Quality Control
- Technological Infrastructure Needs
- Model Standards and Guidelines
- Delivery Strategy Agreement
- Appendices

The detail of the templates in use by different organisations will vary. However, their purpose and overall structure are likely to be similar to that described above.

Therefore, for an organisation to successfully employ BIM, they must have a clear understanding of internal company problems and how much these penalize the company in terms of cost, time, personnel and resources and. Furthermore, the organization must also be aware of how these problems could be minimized with and without BIM as well as how much it will cost, comparatively, to implement BIM (in regards to software licenses, trainings for staff and most importantly in terms of necessary process changes).

### **3.3.5 The Benefits of BIM to the Industry**

BIM supersedes traditional design tools currently in use. Each building component is generated from a product library and has embedded information about its graphics, location and other properties such as materials, specifications, fire ratings, U-values, fittings, finishes, costs, 'carbon content', etc. (BIM Task Group, 2012). The ease of access to this information by the project stakeholders will enable sophisticated applications such as clash detection to be carried out in order to identify problems early on in the design stage and hence reducing problems later at the construction stage.

Gallaher *et al.* (2004) stated that BIM has the potential to change the construction industry and streamline its fragmented operations. However, maximising the benefits of BIM will depend on three main factors:

- i. The amount of information required to be populated into the BIM model so that it can provide the project stakeholders with the “relevant” information for quick and easy undertaking of functions such as costing, alternative design evaluation, energy calculation, construction simulation, quantities, etc.
- ii. Processes (process maps) required to enforce the creation of a collaborative environment within which project information can be generated accurately as and when required by the project stakeholders. Clear roles and responsibilities of each of the partners is a fundamental requirement for such processes.
- iii. The maturity of the project stakeholders to undertake the above two points in a collaborative manner in the interest of the client.

In relation to project life-cycle, McGraw-Hill Construction (2007) identify that the traditional method of project construction generally focuses its effort during the construction phase. This is in contrast to the integrated approach, where the team members work closely during the design phase, resulting in a greater ability to save costs before the construction process commences. Figure 3.3 shows BIM's ability (with a high level of collaboration among partners) to control costs by reducing the cost of design from construction documents to the early design stage.

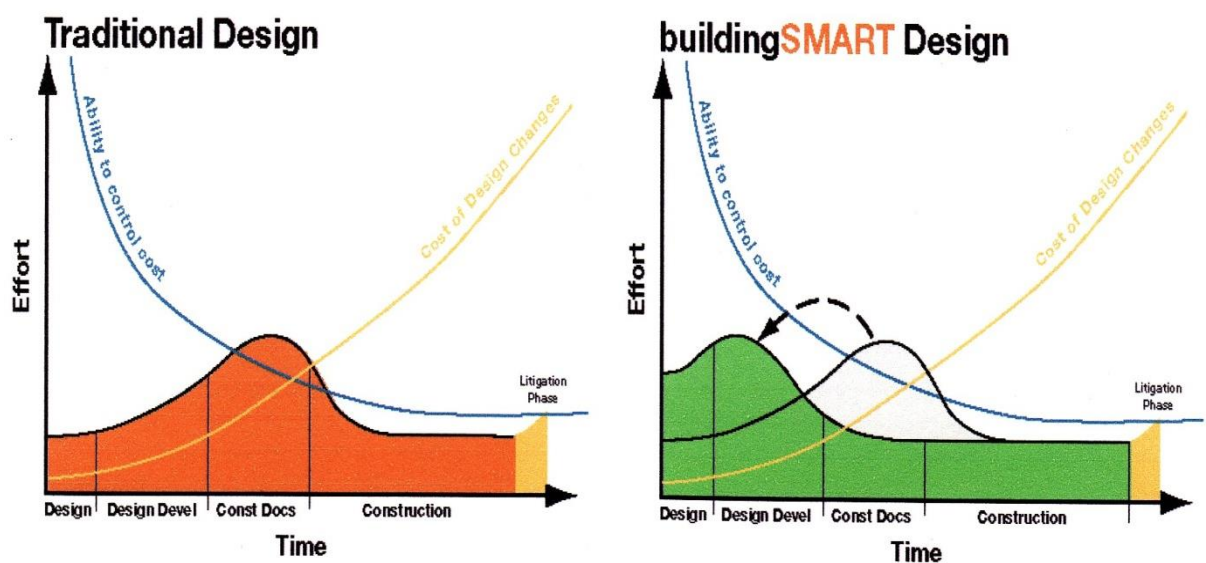


Figure 3.4: BIM Improves Ability to Control Costs  
(McGraw-Hill Construction, 2007)

In generally term, BIM is recognised as providing a wide range of valuable benefits, covering (Langdon, 2012a):

- i. *Design* – improved coordination of design and deliverables between disciplines; improved project understanding through visualisation; improved design management and control, including change control; and improved understanding of design changes and implications through parametric modelling.
- ii. *Compliance* – the ability to perform simulation and analysis for regulatory compliance; and to simulate and optimise energy and wider sustainability performance.

- iii. *Costing/economics* – the capacity to perform cost analysis as the design develops and to check for adherence to budget/cost targets to understand the cost impacts of design changes; and improve the accuracy of cost estimates.
- iv. *Construction* – reduction of construction risks through identification of constructability issues early in the design process; early detection and avoidance of clashes; ability to model impact of design changes on schedule and programme; and the capability to integrate contractor/sub-contractor design input directly to the model.
- v. *Operation and management* – creation of an FM database directly from the project (as built) model; the facility to perform FM costing and procurement from the model; and the ability to update the model with real-time information on actual performance through the life of the building.

The key benefit of BIM is its accurate geometrical representation of the parts of a building in an integrated data environment (CRC Construction Innovation, 2007). Other related benefits are as follows (Azhar *et al.*, 2008):

- i. *Faster and more effective processes* – information is more easily shared, can be value-added and reused.
- ii. *Better design* – building proposals can be rigorously analysed, simulations can be performed quickly and performance benchmarked, enabling improved and innovative solutions.
- iii. *Controlled whole-life costs and environmental data* – environmental performance is more predictable, lifecycle costs are better understood.
- iv. *Automated assembly* – digital product data can be exploited in downstream processes and be used for the manufacturing/assembling of structural systems.
- v. *Better customer service* – proposals are better understood through accurate visualization.
- vi. *Lifecycle data* – requirements, design, construction and operational information can be used in facilities management.

A summary of the benefits of BIM to the project stakeholders can be seen in Table 3.2.

Table 3.2: BIM Applications for Project Stakeholders  
(Azhar *et al.*, 2012)

BIM Application	Clients	Consultants	Contractors	Facility Managers
Visualisation	x	x	x	x
Options Analysis	x	x	x	
Sustainability Analyses	x	x		
Quantity Survey		x	x	
Cost Estimation	x	x	x	
Site Logistics	x		x	
Phasing and 4D Scheduling		x	x	
Constructability Analysis		x	x	
Building Performance Analysis	x	x	x	x
Building Management	x			x

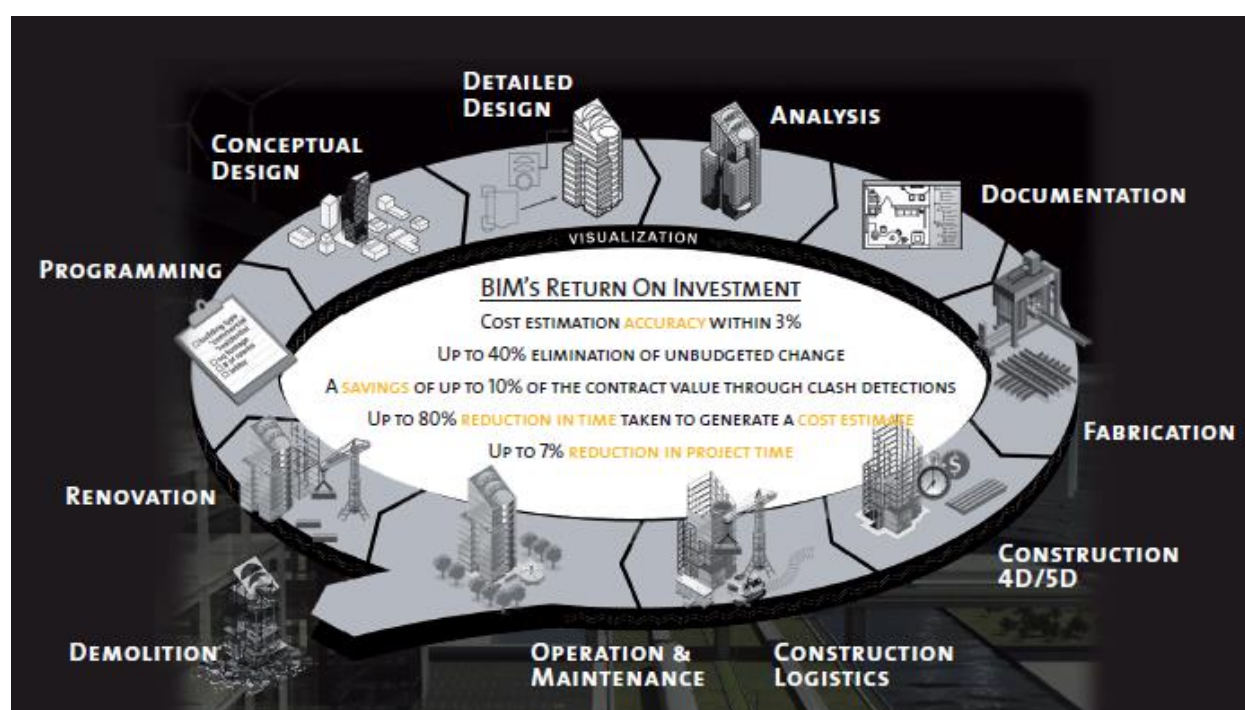


Figure 3.5: BIM Benefits Study by CIFE (Kunz and Gilligan, 2007)

A study undertaken by Stanford University Center for Integrated Facilities Engineering (CIFE) based on 32 major projects that have used BIM indicates the benefits that can be gained, as shown in Figure 3.4 (Kunz and Gilligan, 2007):

- i. Up to 40 percent elimination of unbudgeted change.
- ii. Cost estimation accuracy within 3 percent.
- iii. Up to an 80 percent reduction in the time taken to generate a cost estimate.
- iv. A savings of up to 10 percent of the contract value through clash detections.
- v. Reduction in the time taken to complete a project, by up to 7 percent.

Hence, maximising the full benefits of BIM is highly dependent on the capabilities of project stakeholders to work together. This comes at a time where there is worldwide recognition of the benefits of alternative procurement, specifically to clients, such as partnering in the UK and Integrated Project Delivery in the US. In 2006, the Strategic Forum for Construction launched the 2012 Construction Commitments to bring together the six key areas necessary in order to deliver the 2012 Olympic and Paralympic Games' vision in time, safely and to budget (The Strategic Forum for Construction, 2006). They represent principles to achieve a better industry and exceed current best practices where procurement and integration principles were highlighted as integral to success.

### **3.3.6 Issues and Barriers**

Besides the numerous benefits of BIM for project stakeholders there are also many risks and barriers its execution. In other words, BIM is not a panacea for every project and every firm. BIM is a relatively new approach that is yet to be adopted widely across the construction industry. Despite of it benefits, there are a number of uncertainties and potential risks in its adoption. Azhar *et al.* (2012) divided BIM related risks into two broad categories: (i) Technology-related risks; and (ii) Process-related risks. The following sections present brief discussions on each of these categories.

## **i. Technology-related Risks**

The first technology-related risk is the lack of wide spread BIM standards for model integration and management by multidisciplinary teams. Integrating multidisciplinary information into a single BIM model requires multi-user access to the BIM model. This requires the establishment of protocols in the project planning phase to ensure consistency in information context and formatting styles. Due to the lack of comprehensive standard protocols, each firm attempts to adopt its own “standards”. This could create inconsistencies in the model, which if not properly detected, could lead to an inaccurate and inconsistent BIM model. The project team should perform frequent “model audits” to ensure such issues are avoided (Weygant, 2011).

The “immaturity” of software, particularly in terms of data exchange and inter-operability issues, despite having been reduced during the last 5 years, still poses a considerable risk. Inter-operability is the ability to exchange data between applications to facilitate automation and avoidance of data re-entry. The introduction of Industry Foundation Classes (IFC) and XML Schemas has significantly helped to solve inter-operability issues (Smith and Tardif, 2012). However, both of these approaches have their inherent limitations. Succar (2009) defines inter-operability as ‘the ability of two or more systems or components to exchange information and to use the information that has been exchanged’. As there is no single piece of software that can carry out all tasks throughout the construction process, the need for good inter-operability is essential due to the large number of data exchanges required. Inter-operability is a major issue and international efforts have been mounted to establish exchange formats to address it.

## **ii. Process-related Risks**

The process-related risks include legal, contractual and organisational risks. Firstly, there is a lack of determination of ownership of BIM data and the need to protect it through copyright laws and other legal channels.

Another contractual issue is who will control the entry of data into the model and be responsible for any inaccuracies. Taking responsibility for updating

building information model data and ensuring its accuracy entails a great deal of risk. Requests for complicated indemnities by BIM users and the offer of limited warranties and disclaimers of liability by designers are essential negotiation points that need to be resolved before BIM technology is used. The threat of legal action increases the risk that a business takes when accepting responsibility for a building model (Thompson and Miner, 2007).

Studies by Ashcraft (2008), Davidson (2009) and the BIM Industry Working Group (2011) asserted that due to the large number of companies and stakeholders involved in a construction project, BIM introduces unique issues of responsibility and ownership of building models and intellectual property rights. As the building model is transferred between each stakeholder, it needs to be clear who is responsible for ensuring the model is accurate and up to date (Davidson, 2009). Standard forms of a building contract – including design and consultant appointments – do not currently make specific provision for BIM. The implications for design liability and associated insurance arrangements of the greater integration of design, construction and operation information envisaged under BIM have not yet been fully addressed (Langdon, 2012a).

Davidson (2009) stressed that the deployment of BIM requires the traditional design processes to be changed to suit the workflows associated with BIM. This disruption of workflows is an inevitable aspect of BIM deployment, however, the benefits of BIM will soon outweigh the initial drop in productivity that this will produce.

Poor production information results in delays, extra costs and poor quality, which in turn give rise to disputes over who is responsible for these problems (Richards, 2010). The produced information should be in the same form and quality. Thus enabling it to be used and reused without change or interpretation, whereby an agreed “standard” is required to tackle this issue.

On the other hand, Yan and Damian (2008) carried out a survey on the adoption of BIM with approximately 70 individuals from the US and UK construction industries. They revealed that barriers are usually related to human factors. The respondents perceived the allocation of time and human resources to the training process as the



major obstacle to the adoption of BIM. Other barriers identified in the survey include perceptions that current technology is sufficient (for instance, architects are content with traditional methods to design their projects), people's refusal to learn and their resistance to change, the costs of copyright as well as the unsuitability of some projects to the adoption of BIM.

The MESH Conference series hosted by buildingSMART Australasia in early 2011 identified a number of obstacles facing the wider adoption of BIM drawn from the Productivity in the Buildings Network report and emerging industry understandings (buildingSMART Australasia, 2012). A major stumbling block is the limited availability of building objects incorporating product data in a form suitable for use in BIM. There is a lack of information needed for full performance analysis, product specifications and asset management. Product libraries are being developed by individual entities across the nation at significant cost to individual practices. These, furthermore, fall short of consistency, inter-operability and comprehensive cover of object properties.

Key impediments to the widespread adoption of BIM that were identified at the MESH conferences are as follows:

- Procurement, legal issues and insurance;
- Adoption of common BIM guidelines and information exchanges;
- Multi-disciplinary BIM education;
- Product information and BIM libraries;
- Business process change; and
- Compliance and certification.

One of the most effective ways to deal with such risks is to have collaborative, integrated project delivery contracts in which the risks and rewards of using BIM are shared among the project participants. In November 2008 the AIA took additional steps to lead the design and construction industry towards this more efficient and collaborative working environment through the new standard form contract documents, E202–2008, Building Information Modeling Protocol Exhibit, to provide the contractual structure needed to manage the use of BIM (AIA, 2008). E202–2008 creates an environment that encourages model authors to share their models with

downstream users, other designers, contractors, schedulers, cost estimators and fabricators. This collaborative environment and IPD will be discussed further in the following sections.

### **3.4 Roles and Responsibilities**

The roles and responsibilities of parties involved in the development of a BIM process are no different from those of involved in traditional delivery processes. The main difference is in the effort required by the team members to produce, manage, and deliver more detailed, precise, and accurate information (CURT, 2010).

In the final report for National Building Information Modelling Standards by the National Institute of Building Sciences (NIBS, 2007), the roles and disciplines were defined. Roles refer to the players involved in the business process along with information flows, which are both critical to reducing the cost of data recollection. Individual disciplines are often involved in more than one view as either a provider or consumer of information. The goal is to include both internal and external roles as both providers and consumers use the same information so that data does not have to be re-created and that the authoritative source is the true provider of the information.

At the start of a project, it is important to identify the roles and responsibilities of the design team and of specialist subcontractors who have design content in their work packages (Richards, 2010). It is also necessary to define the roles and responsibilities of individual team members as well as the schedule of responsibilities for deliverables of the overall team with the important factors a being ownership, responsibility and authority.

#### **3.4.1 Consultants**

The consultants consist of a group of designers including architects as well as structural and MEP engineers. A lead designer is responsible for co-ordinating the designs of the various disciplines, checking their information as it is produced and generally ensuring that design work is co-ordinated. In BIM cases, it will also be

important to clarify how this design leadership role differs from the design management role, i.e. the information manager.

There is lack of clarity regarding the role of information or model manager which is frequently used in relation to BIM. However, if the lead designer role remains, it is clear that the information manager's role cannot conflict with the design responsibilities of this role. A sensible interpretation is that the information manager becomes responsible for managing the inputs of each designer into the project model and for ensuring that all of the designers are utilising compatible software using a software sharing matrix. The role might also entail ensuring that the right party is working on the right aspect of the design at a given time by managing the design programme that dictates when each party enters their shared information into the project model (RIBA, 2012).

Consultants (both design and pre-construction) should be bound by metrics established in the BIM implementation plan and monitored closely to avoid unexpected cost overruns or delays due to indecisiveness about design changes. CURT (2010) outlines the responsibilities of the consultant. These have been summarised as follows:

**i. Model Creation**

Determine if the project will have a federated or an integrated modelling approach. The "federated model" concept requires that all component models be combined for coordination only and that each model creator retains responsibility and ownership for their model and work. Whereas the "integrated model" concept requires that all component models exist within one entity that is responsible for maintaining the integrated model.

**ii. Use of Information in the Model**

Determine the decisions regarding how project stakeholders need to interact with the information. This will influence the final deliverable and formats for data access. Required Levels of Details (LOD) should be defined at each level of the model development whereby the required information can be used and extracted from the model.

### 3.4.2 Contractors and Sub-Contractors

Traditionally, contractors deal with all problems, of varying levels of difficulty, which arise at any stage of the design and construction process. The traditional design-bid-build approach limits the contractor's ability to contribute their knowledge to the project during the design phase, when they can add significant value (Eastman *et al.*, 2011). However, to make the best use of BIM as a collaborative tool, a joint contract requires the architect, designers, contractor and sub-contractors to work together from the start of a project. In this context, Winberg and Dahlqvist (2010) and VA (2010) highlighted the contractors and sub-contractors responsibilities as follows:

- i. Acquire detailed information from the BIM model such as getting quantities and relevant information from the model.
- ii. Acquire specific data about all the different construction components that they must purchase or construct.
- iii. Check the structural data analysis that has been made by the designer; such as structural loads, connection reactions, maximum expected moments, shear forces and so on.
- iv. Coordinate the design model with any conflicts to the design model being made prior to fabrication and construction and reported to the design team in the form of a Request for Information (RFI). Clash reports may also be issued by the contractor as background information for RFI's and submittals.
- v. Evaluate the design and construction status: contractors should be able to give input to the model about the construction's progress and be able compare the progress with the actual construction plan.
- vi. Determine the use of BIM for simulations of maintenance, space analysis, and documentation.
- vii. Receive or help create BIM for constructability and handover for field use.

### 3.4.3 Clients

Client teams will evolve to include more advisors who can add specific value to the design, construction and in-use process in order to ensure the success of BIM on each project. The RIBA (2012) proposed a list of individuals that a client teams might comprise of. This included:

*i. Client Representative*

It is a representative from the client body, who has the delegated authority to make key project decisions, to appoint technical advisors and a delivery manager and to act on the advice of such individuals on behalf of the client.

*ii. Technical Advisors*

Advisors are appointed by the client representative to provide them with specific advice on technical items such as the development of an intelligent brief that considers in-use aspects and the preparation of the project Program. It is a representative from the client body, who has the delegated authority to make key project decisions, to appoint technical advisors and a delivery manager and to act on the advice of such individuals on behalf of the client.me or specific aspects of the project that may require strategic advice.

*iii. Delivery Manager*

The Delivery Manager will be accountable to the client representative and their role will entail ensuring that the supply chain is progressing in line with the project programme, evaluating supplier assessment forms submitted at the tender stage and preparing and revising the delivery plan as information is received from the supply chain.

To ensure that projects start on the right path, it is likely that the client representative and their advisors (or a third party) will prepare a delivery plan at the commencement of the project. This would be the primary plan for setting out how project information is to be prepared, who does so, and what protocols and procedures to use. The document would be owned by the client but may be updated and managed using

change control as the supply chain procedures and protocols are expanded and agreed (RIBA, 2012).

### **3.5 Collaborative Environment and BIM**

As mentioned earlier, effective deployment of BIM requires project stakeholders to work together from the early stages of the project to ensure the delivery of a fully integrated and evaluated design. This requires high collaboration levels which can only be achieved by implementing and managing collaborative relationships among project stakeholders.

One key competitive advantage of BIM is its ability to promote greater transparency and collaboration between suppliers and thereby reduce waste (procurement, process and material) through all levels of the supply chain. A key driver of the rapid adoption of BIM by clients and industry is that its benefits are shared by the client and the entire supply chain – with downstream benefits to customers who make use of built assets and, even further, to society at large.

In order to harness the most powerful and sophisticated outcomes of BIM demand high levels of collaboration. Traditionally, design, construction and facility management have been separated at a professional and legal level. Standard construction contracts carefully draw the boundaries between owner, designer and contractor and reject any responsibility of one for the others. This has led to an extremely fragmented and inefficient process that has reduced construction quality and efficiency (HandsonBridgett, 2010).

BIM information is centrally managed, entered once by multiple disciplines, thus it creates the communication base for collaboration. Hence, BIM's power is enhanced by collaboration which in turn is made more effective through BIM.

Graham Watts, OBE, Chief Executive Officer, Construction Industry Council highlighted (HM Government 2012):

*“BIM will integrate the construction process and, therefore, the construction industry. But it will also have many additional benefits for the nation. It will enable intelligent decisions about construction methodology, safer working*

*arrangements, greater energy efficiency leading to carbon reductions and a critical focus on the whole life performance of facilities (or assets). Of even greater importance are the benefits for the economy that will accrue from better buildings and infrastructure delivered by the construction industry”*

The power of collaborative BIM goes beyond improving efficiency. Sustainability, perhaps the most important challenge for the design and construction community, is at the intersection of BIM and collaborative project delivery, drawing strength from both. BIM provides the tools for iteratively analysing and optimizing design. Whilst collaboration provides the content and the creativity that empowers the tools.

### **3.6 The RIBA Plan of Work**

First developed in 1963, the RIBA Plan of Work has been the definitive UK model for the building design and construction process for over half a century, also exercising significant influence on an international stage. The RIBA Plan of Work has been a bedrock document for the architectural profession and the construction industry more generally. It has provided a shared framework for the organisation and management of building projects that is widely used as both a process map and a management tool. Furthermore it offers work stage reference points, which are used in a multitude of contractual and appointment documents and best practice guidelines. It has been amended and updated over time to reflect developments in design team organisation, regulatory regimes and innovations in procurement arrangements. Although these changes have generally been incremental and reactive to changing circumstances rather than strategically driven (RIBA, 2013).

In 2007, the RIBA produced their Outline Plan of Work, the major strength of which is the simplicity of its stages and the clarity of the stage descriptions (RIBA, 2007). However, it only aligns to a single (traditional) procurement route and makes assumptions about the timing of planning applications (RIBA, 2013).

Recently, through its construction strategy, the UK Government called for a more integrated and efficient construction industry, which enshrines principles of sustainability as a matter of course. The UK Government has set out an ambitious vision for the adoption of BIM on all public sector projects. Following this initiative, in 2012 the RIBA created the BIM Overlay to the RIBA Outline Plan of Work, which

provides straightforward guidance on the activities needed at each RIBA work stage to successfully design and manage construction projects in a BIM environment (RIBA, 2012).


RIBA  Outline Plan of Work 2007		
The Outline Plan of Work organises the process of managing, and designing building projects and administering building contracts into a number of key Work Stages. The sequence or content of Work Stages may vary or they may overlap to suit the procurement method.		
RIBA Work Stages	Description of key tasks	OGC Gateways
Preparation	<b>A Appraisal</b> Identification of client's needs and objectives, business case and possible constraints on development. Preparation of feasibility studies and assessment of options to enable the client to decide whether to proceed.	<b>1 Business justification</b>
	<b>B Design Brief</b> Development of initial statement of requirements into the Design Brief by or on behalf of the client confirming key requirements and constraints. Identification of procurement method, procedures, organisational structure and range of consultants and others to be engaged for the project.	<b>2 Procurement strategy</b>
Design	<b>C Concept</b> Implementation of Design Brief and preparation of additional data. Preparation of Concept Design including outline proposals for structural and building services systems, outline specifications and preliminary cost plan. Review of procurement route.	<b>3A Design Brief and Concept Approval</b>
	<b>D Design Development</b> Development of concept design to include structural and building services systems, updated outline specifications and cost plan. Completion of Project Brief. <i>Application for detailed planning permission.</i>	
	<b>E Technical Design</b> Preparation of technical design(s) and specifications, sufficient to co-ordinate components and elements of the project and information for statutory standards and construction safety.	<b>3B Detailed Design Approval</b>
Pre-Construction	<b>F1 Production Information</b> Preparation of detailed information for construction. <i>Application for statutory approvals.</i>	
	<b>F2</b> <i>Preparation of further information for construction required under the building contract. Review of information provided by specialists.</i>	
	<b>G Tender Documentation</b> <i>Preparation and/or collation of tender documentation in sufficient detail to enable a tender or tenders to be obtained for the project.</i>	
	<b>H Tender Action</b> <i>Identification and evaluation of potential contractors and/or specialists for the project. Obtaining and appraising tenders; submission of recommendations to the client.</i>	<b>3C Investment decision</b>
Construction	<b>J Mobilisation</b> Letting the building contract, appointing the contractor. Issuing of information to the contractor. Arranging site hand over to the contractor.	
	<b>K Construction to Practical Completion</b> Administration of the building contract to Practical Completion. Provision to the contractor of further information as and when reasonably required. Review of information provided by contractors and specialists.	<b>4 Readiness for Service</b>
Use	<b>L1</b> <i>Administration of the building contract after Practical Completion and making final inspections.</i>	
	<b>L2</b> <i>Assisting building user during initial occupation period.</i>	
	<b>L3</b> <i>Review of project performance in use.</i>	<b>5 Benefits evaluation</b>
The activities in <i>italics</i> may be moved to suit project requirements, ie: D <i>Application for detailed planning approval;</i> E <i>Statutory standards and construction safety;</i> F1 <i>Application for statutory approvals; and</i> F2 <i>Further information for construction.</i> G+H <i>Invitation and appraisal of tenders</i>		

Figure 3.6: RIBA Plan of Work 2007 (RIBA, 2007)



The RIBA believes that architects have a central role to play in ensuring that the construction industry responds to the opportunities offered by BIM in both public and private sectors. This new overlay, based on the familiar and widely used RIBA Plan of Work, is an important piece of new guidance for architects and co-professionals. As well as setting out BIM activities at each work stage, crucial data “drop points” are identified within the overall project process. The aim is to assist design and construction teams in using BIM to produce a more efficient, intelligent and cost effective design process and to offer enhanced services to clients, particularly in relation to the whole life value of buildings (RIBA, 2012).

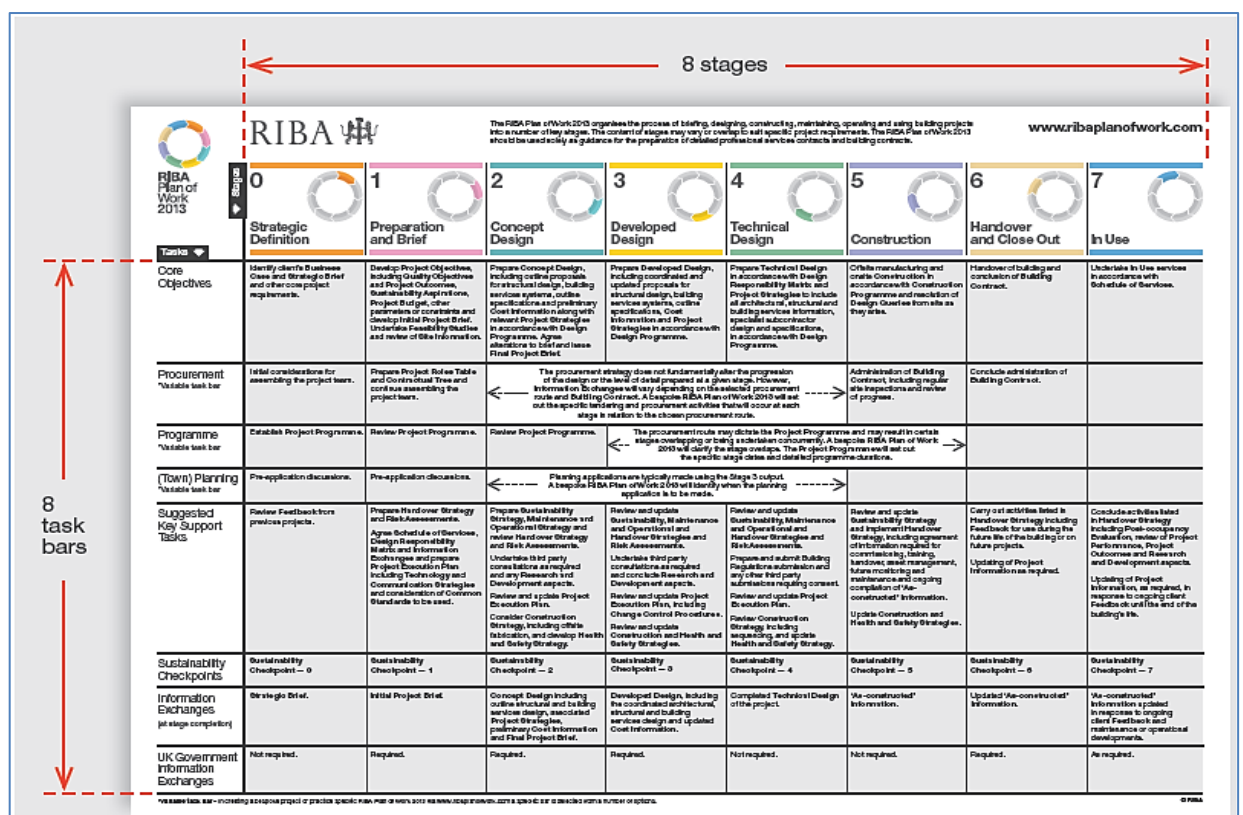


Figure 3.7: RIBA Plan of Work 2013 (RIBA, 2013)

In 2013, The RIBA Plan of Work was developed, building on this valuable heritage and representing the most comprehensive review and development of the work plan to be undertaken since its inception. By developing a new generation the RIBA Plan of Work that incorporates sustainable design principles, provides the infrastructure to support BIM, promotes integrated working between project team members, including the construction team, and provides the flexibility to match procurement approaches to client needs, the RIBA seeks to make an important contribution to this transformation

of the construction sector in the UK and to also have great relevance in the internationally (RIBA, 2013).

The RIBA Plan of Work 2013 organises the process of briefing, designing, constructing, maintaining, operating and using building projects into a number of stages. It details the tasks and outputs required at each stage which may vary or overlap to suit specific project requirements. The RIBA Plan of Work consists of eight stages defined by numbers 0 – 7 and eight task bars as illustrated in Figure 3.6. The main aspects are summarized below:

- acts across the full range of sectors and project sizes;
- provides straightforward mapping for all forms of procurement;
- integrates sustainable design processes;
- maps BIM processes; and
- provides flexibility in relation to (town) planning procedures.

### **3.7 Integrated Project Delivery (IPD)**

According to AIA (2007a), IPD is a “project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimise efficiency through all phases of design, fabrication and construction”. IPD principles can be applied to a variety of contractual arrangements and IPD teams can include members well beyond the basic triad of clients, architects and contractors (McGraw-Hill Construction, 2009). An integrated project includes tight collaboration between the client, the architect, and the main contractor ultimately responsible for the construction of the project, from its early design through to the project handover AIA (2007b). Decker (2009) stated that IPD is a collaborative project delivery method using relational contract principles to harness all of the strengths and capabilities of the client, designers, and constructors and to focus them on one goal: the efficient delivery of the project as a whole.

Collaboration requires replacing traditional processes with a culture of sharing to achieve common goals such as cost effectiveness, improved efficiency and greater quality and innovation while still satisfying the individual's expectations of each partner. Arayici and Alshaw (2008) stated that the main criterion for successful collaboration are (i) improved efficiency, (ii) increased project speed (iii), increased project quality, (iv) project cost reduction, (v) greater reliability and (vi) lower legal cost. Unlike traditional contracts where each party has clear roles and responsibilities defined by their contractual agreement, procurements such as partnering and IPD require more flexible and fluid roles and responsibilities, based on full collaboration between the client, consultant, contractors, subcontractors and suppliers.

Achieving a high level of collaboration requires sharing and “believing” in common objectives, which are to deliver the best service to the client (NASFA *et al.*, 2010). The most important catalyst in achieving this aim is the sharing of risks and rewards by all parties. As IPD is generally a new concept, there is no clear or standard business model that should drive IPD contracts (AIA, 2007a). Also, there is no standard definition for sharing risks and rewards. It is all to be led by the clients. This, once again, highlights the critical role of the clients in this process.

Based on principles of trust and mutual respect, mutual benefit and reward, collaborative decision-making, early involvement of key project participants, early goal definition, intensified planning and open communications, IPD is emerging as an effective project delivery choice for the industry. By leveraging new technologies, like BIM, and new ways of organising and implementing “best-for-project” thinking, teams are achieving significant benefits in terms of project outcomes for all those involved (NASFA *et al.*, 2010). The following sections will offer more detail on IPD.

### **3.7.1 The Principles of IPD**

A basic principle of IPD is the reliance on knowledge integration. Given that IPD encompasses highly collaborative processes that rely on the collective expertise of the project stakeholders (including designers, contractors, subcontractors, and clients). The design intent can be understood and thereby increase the likelihood of project success (Autodesk, 2008).

IPD is centered on a single, multi-party agreement among the client, designer and contractor in which there is a shared project objective with shared risks and rewards. The focus of the IPD process is to deliver a successful project outcome, not a series of individual services (ACI-NA *et al.*, 2012). The agreement defines the working relationship of the three parties where they agree to work towards a common outcome and agree to avoid change orders and lawsuits.

IPD is built on mutual trust. Jones in McGraw-Hill Construction (2009) stressed that, if effectively structured, trust-based collaboration encourages parties to focus on project outcomes rather than their individual goals. Without trust-based collaboration, IPD will falter and participants will remain in adverse and antagonistic relationships that plague the construction industry today. IPD promises better outcomes, but outcomes will not change unless the people responsible for delivering those outcomes also change. Thus, achieving the benefits of IPD requires that all project participants embrace the Principles of Integrated Project Delivery as follow (AIA, 2007a, 2007b; McGraw-Hill Construction, 2009):

i. *Mutual Respect and Trust*

In an integrated project, client, designer, consultants, constructor, subcontractors and suppliers understand the value of collaboration and are committed to working as a team in the best interests of the project.

ii. *Mutual Benefit and Reward*

As the integrated process requires early involvement by more parties, IPD compensation structures recognize and reward early involvement. Compensation is based on the value added by an organisation and it rewards “what’s best for project” behavior, such as by providing incentives tied to achieving project goals.

iii. *Collaborative Innovation and Decision Making*

Innovation is stimulated when ideas are freely exchanged among all participants. In an integrated project, ideas are judged on their merits, not on the author’s role or status. Key decisions are evaluated by the project team and, to the greatest practical extent, made unanimously.

iv. Early Involvement of Key Participants

In an integrated project, the key participants are involved from the earliest possible moment. Decision making is improved by the influx of knowledge and the expertise of all key participants. Their combined knowledge and expertise is most powerful during the project's early stages where informed decisions have the greatest affect.

v. Early Goal Definition

Project goals are developed early, agreed upon and respected by all participants. Insights from each participant are valued in a culture that promotes and drives innovation and outstanding performance, holding project outcomes at the center within a framework of individual participants' objectives and values.

vi. Intensified Planning

The IPD approach recognizes that increased effort in planning results in increased efficiency and savings during execution. Thus the thrust of the integrated approach is not to reduce design effort, but rather to greatly improve the design results, streamlining and shortening the much more expensive construction effort.

vii. Open Communication

IPD's focus on team performance is based on open, direct, and honest communication among all participants. Responsibilities are clearly defined in a no-blame culture leading to the identification and resolution of problems, not determination of liability. Disputes are recognized as they occur and promptly resolved.

viii. Appropriate Technology

Integrated projects often rely on cutting edge technologies. Technologies are specified at project initiation to maximize functionality, generality and interoperability. Open and interoperable data exchanges based on disciplined and transparent data structures are essential to support IPD. As open

standards best enable communications among all participants, technology that is compliant with open standards is used whenever possible.

ix. Organisation and Leadership

The project team is an organisation in its own right and all team members are committed to the project team's goals and values. Leadership is taken by the team member most capable with regard to specific work and services. Often, design professionals and contractors lead in areas of their traditional competence with support from the entire team, however specific roles are necessarily determined on a project-by-project basis. Roles are clearly defined, without creating artificial barriers that curtail open communication and risk taking.

The American Institute of Architects (AIA, 2007b) also highlighted that the IPD projects are best suited to business models that:

- i. Promote the early involvement of key participants.
- ii. Equitably balance risk and reward.
- iii. Have compensation structures that reward "best for project" behavior, such as "open book" or incentives tied to the achievement of project goals.
- iv. Clearly defined responsibilities.
- v. Implement management and control structures built around team decision making with facilitation, as appropriate.

### **3.7.2 The Benefits of IPD**

IPD results in greater efficiencies. The UK's Office of Government Commerce (OGC) estimates that savings of up to 30 percent in the cost of construction can be achieved where integrated teams promote continuous improvement over a series of construction projects. OGC further estimates that single projects employing integrated supply teams can achieve savings of between 2-10 percent in the cost of construction (OGC, 2007).

In 2008, the AIA California Council and the AGC conducted a survey about IPD, which and it is found that almost 40 percent of respondents had some experience with it and/or most were interested in trying it (AIA, 2008a). Figure 3.7 reports the values of IPD as mentioned by the respondents.

Reduced time needed for design and construction	46%
Higher quality projects	58%
Overall cost saving in project design and construction	61%
Reduced change orders and other project delays	71%
Reduced conflict by encouraging all parties to work collaboratively	84%

Figure 3.8: IPD Survey Results by AIA and AGC  
(McGraw-Hill Construction, 2009)

Beyond the above benefits, IPD provides positive value propositions for the three major project stakeholders (AIA, 2007b):

**i. Clients**

- a. Early and open sharing of project knowledge streamlines project communications and allows clients to effectively meet their business enterprise goals.
- b. Strengthens the project team's understanding of the client's desired outcomes, thus improving the team's ability to control costs and manage the budget.

**ii. Contractors**

- a. IPD allows contractors to contribute their expertise in construction techniques early in the design process resulting in improved project quality and financial performance during the construction phase.
- b. The contractor's participation during the design phase provides the opportunity for strong pre-construction planning, a more timely and informed

understanding of the design, anticipation and resolution of design-related issues, and the visualisation of construction sequencing prior to its start, and improving cost control and budget management.

**iii. Consultants**

- a. Allows the designer to benefit from the early contribution of contractors' expertise during the design phase, such as accurate budget estimates to inform design decisions and the pre-construction resolution of design-related issues resulting in improved project quality and financial performance.
- b. Increases the level of effort during early design phases, resulting in reduced documentation time, and improved cost control and budget management.

**3.7.3 Differences between IPD and Traditional Procurement Approaches**

In a truly integrated project, the project flow from conceptualization through to implementation and closeout differs significantly from a non-integrated project. Conventional terminology, such as schematic design, design development and construction drawings, create workflow boundaries that do not align with a collaborative process (AIA, 2007b).

Traditional delivery and contracting approaches contemplate separate silos of responsibility that, in practice, yield inefficiencies whenever there is a hand-off from one silo to another (AIA, 2007a). IPD, however, represents a behavioural change in the industry by breaking down the silos of responsibility, requiring close cooperation among all major participants, and aligning participants' success to project success.

Traditional project phases will be adjusted and refined to accommodate an integrated project team and their project participation. Construction experience deployed early in the design process results in better decisions regarding what will be built, in line with decisions about who is going to build it and how it will be built.



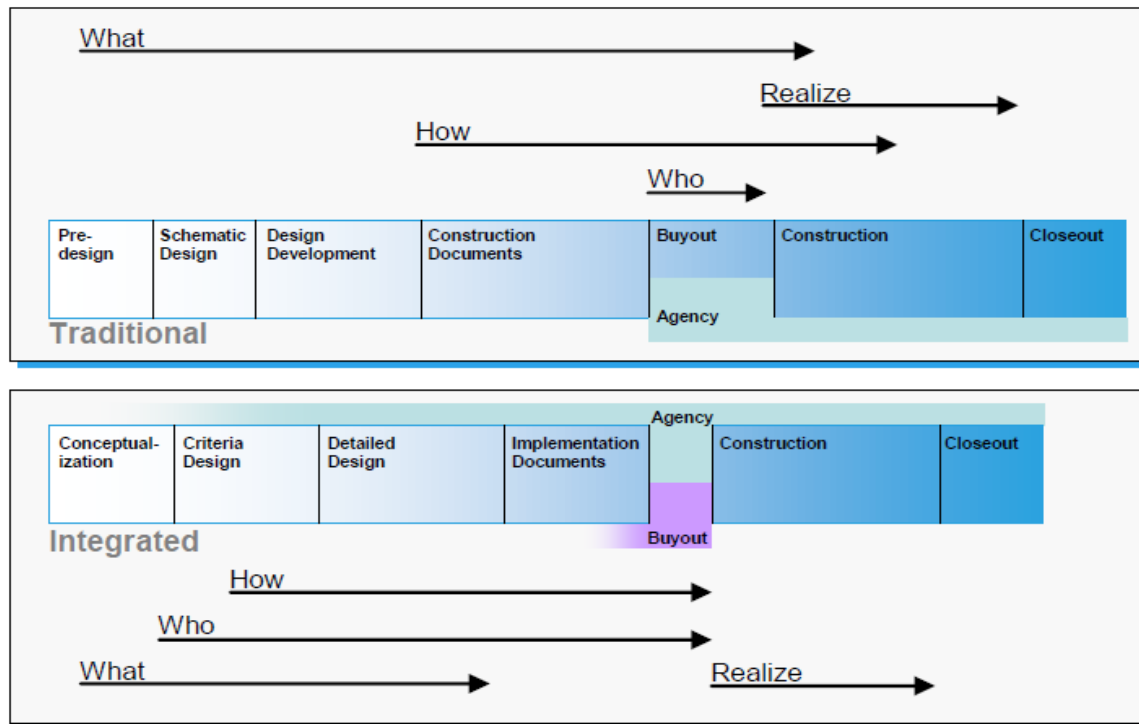


Figure 3.9: Comparison Between Traditional Procurement and the IPD Approach (AIA, 2007b)

In addition to shifting design decision-making forward, the redefinition of phases is driven by two key concepts: the integration of early input from consultants, contractors, installers, fabricators and suppliers and the ability to model and simulate the project accurately using BIM tools. These two concepts enable the design to be brought to a much higher level of completion before the documentation phase begins. Thus the first three phases of the integrated project: conceptualization, criteria design, and detailed design involve more effort than their counterparts in the traditional flow. The result is that the project is defined and coordinated to a much higher level prior to the construction's start than is typical with traditional delivery methods, enabling a more efficient construction phase and a potentially shorter construction period (AIA, 2007a).

Table 3.3 shows a comparison between Traditional Project Delivery methods and IPD ones. In practice, integrated project delivery exhibits fundamental differences from traditional models in two primary areas: team assembly and project phasing/execution.

Table 3.3: Traditional Project Delivery Methods vs Integrated Project Delivery (AIA, 2007a)

Factor	Traditional Project Delivery	Integrated Project Delivery
Teams	Fragmented, assembled on a “just-as-needed” or “minimum-necessary” basis, strongly hierarchical and controlled	An integrated team entity composed of key project stakeholders, assembled early in the process, open and collaborative
Process	Linear, distinct, segregated; knowledge gathered “just-as-needed” information hoarded; silos of knowledge and expertise	Concurrent and multi-level; early contributions of knowledge and expertise; information openly shared; stakeholder trust and respect
Risks	Individually managed, transferred to the greatest extent possible	Collectively managed, appropriately shared
Compensation/ Reward	Individually pursued; minimum effort for maximum return; (usually) first-cost based	Team success tied to project success; value-based
Communications/ Technology	Paper-based, 2 dimensional; analog	Digitally based, virtual; Building Information Modelling (3, 4 and 5 dimensional)
Agreements	Encourage unilateral effort; allocate and transfer risk; no sharing	Encourage, foster, promote and support multi-lateral open sharing and collaboration; risk sharing

The “MacLeamy Curve” in Figure 3.10 shows how the IPD approach transforms the traditional phases of projects. According to the AIA (2007a) the function of the IPD approach is to optimise project results, increase project worth to the client, reduce waste, and maximize efficiency through all phases of design, fabrication and construction. IPD involves a joint contract requiring architects, designers, general contractors and key trade contractors to work together from the start of a project, making the best use of BIM as a collaborative tool.

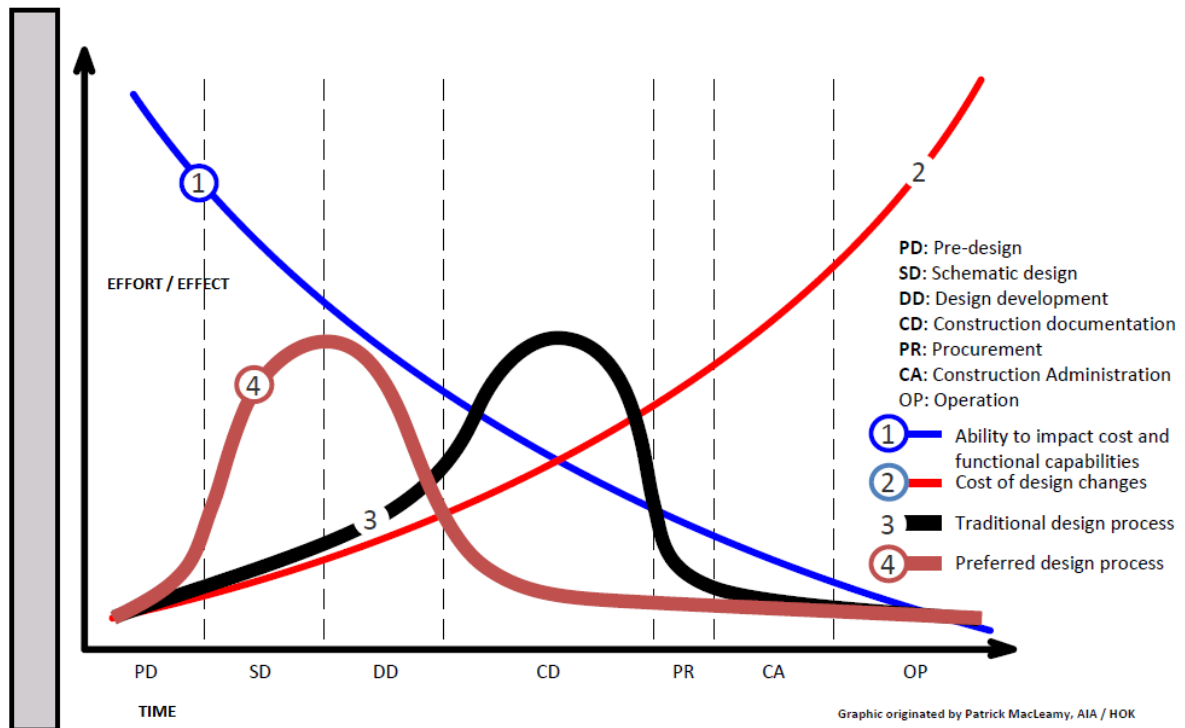


Figure 3.10: The “MacLeamy Curve” IPD Impact on the Design Process (MacLeamy, 2004)

### 3.7.4 Roles and Responsibilities

IPD seeks to break down the traditional contracting barriers, with separated silos and responsibilities, by having all major participants focus on achieving shared goals. IPD encourages early contribution of knowledge and experience and relies on the proactive involvement of the main participants. Responsibility is placed on the most able person with decisions being made on a “best for project” basis AIA (2007b).

IPD has a clear defined work scope for each participant where the consultants and the contractors still remain primarily responsible for design and construction respectively. The section below highlights the separate roles and responsibilities of the consultants, contractors and the client (AIA, 2007a):

#### *i. Consultants*

- a. Lead and actively involved in the design process where other team members will also participate.

- b. Are required to perform in an earlier stage certain services that are traditionally performed later in the project. The resulting advancement of services potentially increases the volume of services provided in the design phase.
- c. Frequent interactions with other team members during the design phase necessitates that designers provide numerous iterations of their design documents to other team members for their evaluation and input.
- d. An additional responsibility to track throughout the design phase both the status of iterations provided to other team members and the nature and substance of the input received from them.
- e. Communications are facilitated by the collective team and do not rely on a single gate-keeper.

*ii. Contractors*

- a. Provide strategic services such as schedule production, cost estimating, phasing, systems evaluation, constructability reviews, and early purchasing programs at early stage of involvement.
- b. Provide expertise and fully participate in the design of the project. The result is a greater role in commenting on and influencing design innovation.
- c. Provide, on a continuing basis, estimating services and/or target value design services during the design phase.

*iii. Client*

- a. Actively involved in evaluating and influencing design options.
- b. Participate in establishing design alternatives at an earlier stage than is typical in a traditional project.
- c. Involved more often to assist in resolving issues that arise on the project-related specifics and be required to act quickly in this regard to allow the project to continue efficiently.

### **3.7.5 Risks, Legal Considerations and Reward Sharing**

Risk is defined as the potential of loss (an undesirable outcome, however not necessarily so) resulting from a given action, activity and/or inaction. Yet the AIA considers risk a function of the likelihood of a loss weighted by its severity. In contrast, exposure to risk is the number of possible avenues by which loss can occur. However, the business risks faced by design and construction, such as cost overruns, failure to meet project goals and market uncertainties, occur far more often and are far more serious than liability risks.

IPD reduces such risks by linking compensation to achievement of project goals, where all or part of the participants' profit is placed at risk if project performance does not meet or exceed project goals (Ashcraft, 2012). Thus, IPD contemplates a high degree of collaborative effort. In many cases, project participants share, to one degree or another, in the success or failure of the overall venture. In this regard, IPD arrangements are more likely to be classified as joint ventures, where risk is a joint liability.

As project participants remain responsible for their individual tasks, an IPD approach should not alter traditional requirements with respect to professional or business roles. Collaboration between consultants and contractors does not automatically lead to a collaborative environment, where contractors are required to perform design services. They need to handle the task consistent with registration requirements. This is no different than in the case under a non-collaborative approach (AIA, 2007a).

The Associated General Contractors (AGC) and the AIA have recently issued contract documents that support IPD (HandsonBridgett, 2010). The difference in IPD practice also reflects differences between project teams and between different projects. IPD documents must reflect the participants' different characteristics, capabilities and preferences. At a minimum, issues such as project duration, project size, the size and financial capability of the participants, type of financing, project complexity, prior IPD experience and risk tolerance all affect how IPD is implemented. Each project, therefore, needs to be separately handled.

Regardless of the type of project delivery system selected, the contractual arrangement by which the parties are compensated must also be established (ACI-NA *et al.*, 2012). This is part of the client's overall project management responsibilities, separate from but related to the selection of the project delivery approach. The basis for compensation has to depend on and must be consistent with the selected project delivery approach and the distribution of risk and responsibility between the client and those delivering the project.

Shared risk/reward also increases commitment to the project and serves to align the parties to the project objective (Ashcraft, 2012). Shared reward not only makes risk more tolerable, it provides a basis for IPD projects' acceptance. Shared risk and reward should extend to all key IPD participants, not just the owner, contractor and designer including those who have had a significant effect on project outcome, particularly if the project outcome is tied to their successful working with others.

### **3.8 Challenges Facing the Implementation of IPD**

In traditional contracts each party has clear roles and responsibilities towards the achievement of its contractual agreement for the project. Whereas IPD's principles are based on full collaboration between the client, consultant, contractors, subcontractors and suppliers starting at the early design stages and continuing until the project handover.

It requires an increasing effort from designers and contractors aiming to reduce documentation time, improve cost control and budget management. This creates a "fluid" situation and questions such as "who should do what" and "why", which could create tension between partners and hence reduce the level of collaboration. Such tensions have the potential to halt collaboration altogether. This important issue raises the need for new contract arrangements to be made at the early stage of the project. In addition it highlights the importance of client leadership in establishing a framework for IPD implementation.

On the other hand, achieving a high level of collaboration requires sharing and "believing" in common objectives, which are to deliver the best service to the client. The most vital catalyst in achieving this aim is the ability to share risks and rewards.

As IPD is generally a new concept, there is no clear or standard business model that should drive IPD contracts. Also, there is no typical definition for sharing risks and rewards. It is all to be led by clients. This, yet again, highlights the critical role of the clients in this process.

Trust is another essential factor which underpins successful collaboration between project stakeholders. Obtaining an optimal collaboration requires a transparent process, open information sharing, shared risk and reward, value-based decision-making and utilization of full technological capabilities and support (AIA, 2007a). Each member's success will rely on the team, which is tied up in the success of the project. Client organisations can play a leading role in establishing trust between the project stakeholders as being the ultimate owner and beneficiary.

Achieving the above is challenging and highly dependent on the maturity of project stakeholders, but most importantly on the maturity of Client organisation. The more mature the latter originations are the greater likelihood of the selection of appropriate partners and the creation of effective contractual arrangements and collaborative environment based on trust and risk/reward sharing.

### **3.9 IPD and Client Organisations**

The key to successful IPD is assembling a team that is committed to collaborative processes and capable of working together effectively. The American Institute of Architects (AIA, 2007a) proposed that the participants must:

- i. Identify, at the earliest possible time, the participant roles that are most important to the project.
- ii. Pre-qualify members (individuals and firms) of the team.
- iii. Consider interests and seek involvement of select additional parties, such as building officials, local utility companies, insurers, sureties, and other stakeholders.
- iv. Define, in a mutually understandable fashion the values, goals, interests and objectives of the participating stakeholders.

- v. Identify the organisational and business structure best suited to IPD that is consistent with the participants' needs and constraints. The choice should not be rigidly bound to traditional project delivery methods, but should be flexibly adapted to the project.
- vi. Develop project agreements to define the roles and accountability of the participants. The project agreements should be synchronized to assure those parties' roles and responsibilities are defined identically in all agreements and are consistent with the agreed organisational and business models. Key provisions regarding compensation, obligation and risk allocation should be clearly explained and should encourage open communication and collaboration.

It is clearly indicated that recognition of the client role is the main factor to bring about an effective deployment of IPD. Robust client leadership is necessary to ensure effective actions are taken to fully realise the potential of IPD's capabilities to improve the performance and quality of projects and to reduce completion costs and time.

As explained in the previous section, client organisations, more than any other partner, should drive the degree of collaboration. They can influence collaboration early in a project's life through their procurement and contracting processes. In fact, clients may establish the level of integration that they may expect on each of their projects. NASFA *et al.* (2010) stated three collaborative levels that represent the typical space within which clients can move. These collaboration Levels are detailed in Figure 3.10:

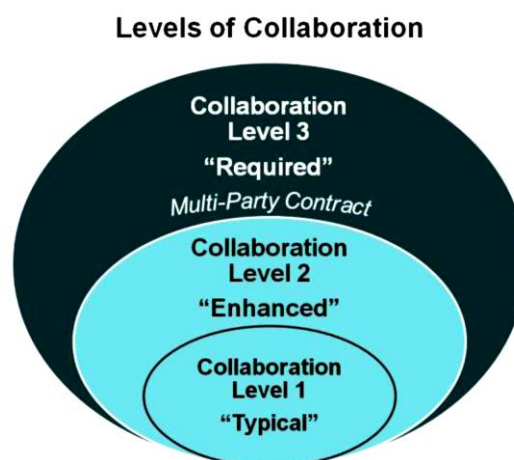


Figure 3.11: The Three Levels of Collaboration  
(NASFA *et al.*, 2010)



1. Collaboration Level One – Typical: collaboration not contractually required
2. Collaboration Level Two – Enhanced: some contractual collaboration requirements
3. Collaboration Level Three – Required: collaboration required by a multi-party contract

In general, client organisations' approach (the level of collaboration) may vary as a consequence of legislative restrictions, policy limitations or cultural barriers.

### **3.10 The Need for Tools to Transfer Client Organisations to BIM/IPD-Based Ones**

The very essence of BIM is moving away from drawings to a model: one which contains more information than a graphical representation of an object. In BIM, an object could contain a wealth of data which might include the shape and size; type of object; colour and weight; manufacturer, part number, serial number; performance; cost of object and fitting; maintenance data, fitting/installation date; and much more. Based upon this information, the drawings, bills of quantities, construction schedules, visualisations, fabrication instructions, overall costs etc. would all be created and updated. Therefore, a whole set of tasks traditionally handled independently by architects, engineers, construction companies and even clients, such as drawing management, costing and scheduling, construction management in all its forms, etc. suddenly become interrelated with data management tasks. Document control, publication, co-ordination, communication, RFI, etc. become data management tasks. Effective management of this task can bring significant advantages to projects but it must be supported by appropriate work practices.

A map based tool is therefore required to be produced, which could effectively represent the relationship between different types of information providing a clear and concise method of tracking a project's progress for clients and stakeholders as well as a communication tool for the team to refer to. In addition, such a map should be a process based one so that it can provide client organisations with guidelines to effectively exercise their leadership to bring about change and to effectively implement

BIM in their organisations. This is particularly important for IPD where each phase of the design and construction may require different processes to be developed.

Kagioglou *et al.* (2002) expressed that each business process needs to be mapped and used as a means of illustrating the various processes and information flows within the design and construction process. They also argued that it has proved to be beneficial in terms of transparency and communication as well as a mechanism for managing project data and forming the basis for continuous improvement.

### **3.11 Summary**

Working in a collaborative environment not only relies on the project team but also on how well the team can successfully share the project information. There are two key challenges in this regard: the quality of the information being generated and used in the project and the means by which this information is communicated and shared amongst the project team. Such information needs to be managed so that it can be easily retrieved or accessed in the required format as and when it is needed.

The presence of BIM opens up a range of possibilities by which project information can be held centrally as a 'single' model. BIM is a collaborative way of working, underpinned by digital technologies, which provide a major step-change in the ability of design and construction teams to structure, exchange and share information. However, the deployment of BIM requires the traditional design processes to be changed to suit the workflows associated with BIM. In-line with this need, IPD was introduced - "a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimise efficiency through all phases of design, fabrication and construction". This chapter highlighted and discussed the principles of BIM and IPD and how such technology and delivery processes can provide client organisations with detailed processes to effectively exercise their leadership to bring about change and to effectively implement BIM in their organisations. The following chapter will discuss and highlight processes and process based tool, which are required to achieve the aim of the study.

# **CHAPTER 4**

## **Process and Process Protocol**

### **4.1 Introduction**

The previous chapter highlighted the importance of BIM and IPD whereby collaborative decisions can be made for the benefit of the entire project. Improvements in efficiency and productivity resulting from BIM will cause the unit cost of design and construction services to lessen while their quality, value and profitability increase (Smith and Tardif, 2012). Hence, a procurement approach such as IPD is becoming an increasingly important alternative to traditional delivery approaches (McGraw-Hill Construction, 2009).

Smith and Tardif (2012) believe that the implementation of BIM is causing the construction industry to cast a critical eye on other business processes and ask how these could also be reorganised in a more structured way. They proposed that BIM be part of all internal business processes, whether they relate to design or construction. Every organisation should routinely analyse its information flow to determine when information should be created and when it should be retrieved from or by others. As part of this process, systematic procedures are required for retrieving and validating information received from others.

BIM could affect several business functions such as planning, sales, design, estimating, scheduling, material management, contracting, cost control, quality management, safety management, human resource management, financing, general administration, and research and development (Jung and Joo, 2011). This large number of functions reflects the importance of involving key stakeholders and decision-makers that can contribute to both the implementation and sustainability of BIM. Thus, reinforcing their role in any proposed collaborative framework before, during, and after BIM's utilisation, is critical.

The previous chapter also discussed the RIBA Plan of Work which provides a shared framework for the organisation and management of construction projects. It is widely used as both a process map and a management tool. Moreover it provides important work stage reference points that can be used in different contractual and employment documents in addition to best practice guidance.

This chapter will further discuss the importance of business processes. In particular it will address why such processes should be modelled. Later in this section, a structured way to implement business processes using project phases guided through the RIBA plan of work will be explained. Finally the process protocol is proposed for handling and delivering the construction processes as supported by the implementation of BIM and IPD.

## **4.2 Definition of a Business Process**

A business processes are defined as "a coordinated and standardized flow of activities performed by people or machines, which can traverse functional or departmental boundaries to achieve a business objective that creates value for internal or external customers" (Chang, 2005). Whereas Davenport (2005) defined a business process as how an organisation does its work. Often, processes even cut across organisational boundaries (Kock Jr and McQueen, 1996). Furthermore their sequence of related activities and operations always link into the organisation's overall strategy and plans for the effective and efficient delivery of services to its customers.

The business model used in the construction industry has essentially remained the same since the Renaissance era (Heller, 2008). However, due to the increasing demands of clients stakeholders are now beginning to explore ways in which they can change their business processes in order to maximise the benefits of available technology.

In August 2004 the Construction Users' Round Table (CURT, 2004) published a white paper, entitled Collaboration, Integrated Information and the Project Lifecycle in Building Design, Construction and Operation, which recommended BIM as a way to change the construction industry's business processes. BIM needs to be refined for generating and leveraging building data to design, construct and operate the building

during its lifecycle, as was discussed in the previous chapter. Clear understanding and management of this process will enable the successful implementation of BIM. Yet its implementation needs to be deployed through the creation of process maps.

During the creation of process maps, complex business functions can be broken down into simpler activities. This top-down technique is referred to as functional decomposition or process decomposition as shown in Figure 4.1. This technique allows for greater understanding and verifying of business objectives.

The level of decomposition and the rigor applied to the analysis of any business process depends on the aim and scope of the project. Not all projects require analysis to the elementary process level. However, it is important to identify the appropriate point at which to stop. A level of decomposition that is coherent and has meaning to the business must be determined.

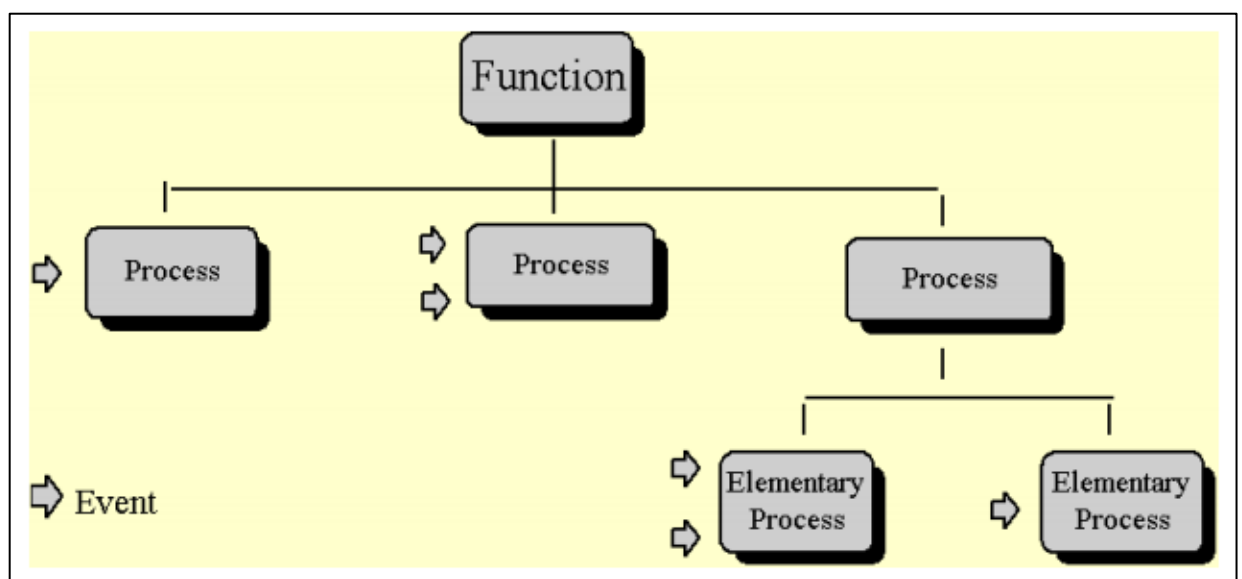


Figure 4.1: Process Decomposition (British Columbia, 1996)

### 4.3 Business Process Management

Many organisations focus on a process-oriented way of managing their business and attempt to improve performance by applying Business Process Management (BPM) methods. BPM has become an essential way of managing business processes and it is the way in which an organisation can improve its business by focusing on its processes. With BPM, organisations can perform process improvement in a

coordinated way, exploring opportunities for re-using, combining or standardising processes across the organisation or in collaboration with other organisations.

BPM is a structured, coherent, and consistent way of understanding, documenting, modelling, analysing, simulating, executing and continuously changing end-to-end business processes and all involved resources in light of their contribution to business performance (Vom Brocke and Rosemann, 2010).

Business process management is considered to be the main tool to bring changes to organisations. It now allows organisations to integrate business processes with technological innovations and improve performance quickly according to the changing needs of customers, regulatory compliances, among others.

Chang (2005) highlighted that the latest developments in BPM can lead to a framework to better integrate businesses and IT. Business processes are separated from the applications while business process models are developed to suit the company's business strategy and their IT strategy. The business process models in the middle layer should be flexible enough so as to allow the company's existing business processes to be adapted or redesigned quickly to cope with the company's strategic development, as well as to allow the existing application software to be reused and integrated easily into any new business context.

## **4.4 Process Modelling**

An essential part of BPM as a management concept is business process modelling. The modelling of business processes requires an abstraction from real-world procedures in order to map them into process models. They are created using one of several modelling techniques according to the exact type of business and purposes for modelling.

Process modelling is a central element in any approach to BPM. It is merely a tool that provides a means of communicating complex business functions in a form more easily understandable to people. Effective design of business processes allows individuals to work together more efficiently. The goal of a process model is to capture working

procedures at a level of detail appropriate to fulfil its envisioned tasks (Vom Brocke and Rosemann, 2010).

Process models reflect the business activities and their relationships in an organisation. They can be used for analysing such as cost, resource utilization or process performance. They can also be used for automation. During the development of process modelling, data flow preconditions and the effects of activities must be specified as well as the control flow between activities and branching conditions (Awad *et al.*, 2010).

With the current uptake of BIM, process modelling can play a vital role in improving the construction industry by underpinning the application of BIM and IPD. Use of BIM goes beyond the planning and design phases of the project, it supports processes throughout the project lifecycle. Therefore, the development of process models for BIM requires thorough investigation and the involvement of all stakeholders.

To enable an analysis of process modelling, process maps need to be developed. Process maps depict the roles, activities, and interactions of all participants in a process. Participants might include people, roles, departments, computer applications and external organisations. The following section explains this concept in detail.

## **4.5 Process Mapping**

Process mapping is the identifying, documenting, analysing and developing of an improved process (Anjard, 1998). In business, process mapping is the task of defining what a business does, who is responsible and the standard by which the success of the business processes can be judged. This is not to be confused with business process modelling, which is focused more on the improvement of business processes (Appian, 2013).

In the development of a BIM execution plan, process maps are used as a visual aid for organizing work procedures with links between inputs, outputs, and tasks (Klotz *et al.*, 2008). It also provides a detailed plan for execution of each BIM Use. BuildingSMART International (Wix and Karlshoej, 2010) highlighted that the purpose

of a process map is to help provide understanding of how work is undertaken in order to achieve a well-defined objective. The main features of this plan are that it:

- i. has a Goal
- ii. has specific inputs (typically from other exchange requirements and from other data sources)
- iii. has specific outputs (typically to other exchange requirements)
- iv. uses resources
- v. has a number of activities that are performed in some order
- vi. may affect more than one organisational unit
- vii. creates value of some kind for the customer

A process map can be shown at various levels of detail. Some have described this as “peeling the onion” (Anjard, 1998). It should be developed from a top-down approach, where one should begin mapping at the highest level down to the lowest, where the number of levels are determined by the scope of the system.

A key requirement of process maps is prior understanding of process modelling techniques. The following sections will highlight well-known process modelling techniques which are widely used, such as Data Flow Diagram (DFD), IDEFØ and Business Process Model and Notation (BPMN).

#### **4.5.1 Data Flow Diagram**

Data Flow Diagram (DFD) as described by DeMarco (1979) is a traditional systems analysis which has been widely used as a basic approach to software development projects. It shows what kinds of information can be input into, and output, from the system, where the data will come from and go to, and where it will be stored. It does not display information about the timing of processes, or information about whether processes will operate in sequence or in parallel (which is shown on a flowchart).



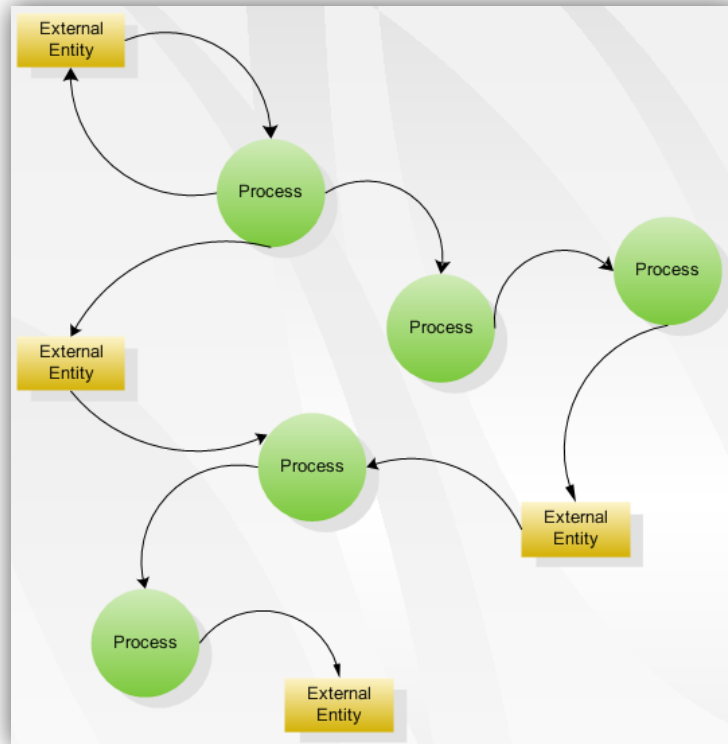


Figure 4.2: Basic Concept of Data Flow Diagram (DFD) (Edraw, 2014)

DFDs consist of four basic components that illustrate how data flows in a system: entity, process, data store and data flow as shown in Figure 4.2.

**Entity** is the source or destination of data. The source in a DFD represents these entities that are outside the context of the system.

**Process** is the manipulation or work that transforms data, performing computations, making decisions (logic flow), or directing data flows based on business rules. In other words, a process receives input and generates some output.

**Data Store** is where a process stores data between processes for later retrieval by that same process or another one. Files and tables are considered data stores.

**Data Flow** is the movement of data between the entity, the process, and the data store. Data flow portrays the interface between the components of the DFD. Data flow is represented by an arrow, where the arrow is annotated with the data name.

DFD has been used in construction process modelling, for instance in a study on communications between participants (Abou-Zeid and Russell, 1993) and modelling the building design process (Austin *et al.*, 1996; Baldwin *et al.*, 1999). Austin *et al.* (1996) use DFD to define individual design tasks as processes, design information flows as flows, drawings as data stores and stakeholders such as clients and local authorities as external entities.

The advantages of DFD is that it is a simple graphical technique which is easy to understand, it helps in defining the boundaries of the system and is also useful for communicating current system knowledge to the users. However, DFD undergoes lot of alteration before it is passed to the users, which makes the process a little slow. Sometimes, it makes the programmers confusing towards the system being developed.

#### **4.5.2 IDEFØ**

A systematic description method is required to describe construction in a way that is clear to all parties and enables communication between them (Björk and Wix, 1991). IDEFØ is introduced which is based on the SADT (Structured Analysis and Design Technique) and was originally developed by Ross (Ross, 1977; Ross and Schoman Jr, 1977). In his introduction to SADT, Ross stressed that with the use of SADT, human thought can be expressed concisely and clearly (Marca and McGowan, 1987). Since the emergence of SADT, it has been widely used in the development of Computer Aided Engineering (CAE) application systems. The US Air Force Integrated Computer Aided Manufacturing (ICAM) adopted the technique and this resulted in the IDEFØ (ICAM Definition Method Zero), which has been widely used in the STEP (STandard for the Exchange of Product model data) initiative to describe activity based models.

An important feature of the IDEFØ is its time dependency, i.e. activities are sequenced according to their time. This criterion makes IDEFØ different from other structured techniques such as Data Flow Diagrams (DFD). It goes beyond data flow charts in that it describes both physical and informational objects in the process.

IDEFØ models are co-ordinated sets of diagrams, which adopts top-down approach whereby high level activities are decomposed into low level activity exposing more and more, details of the system being analysed. This is shown in Figure 4.3. In each IDEFØ diagram, activity is represented by a box, and the relationship and flow of data between activities by lines and arrows.

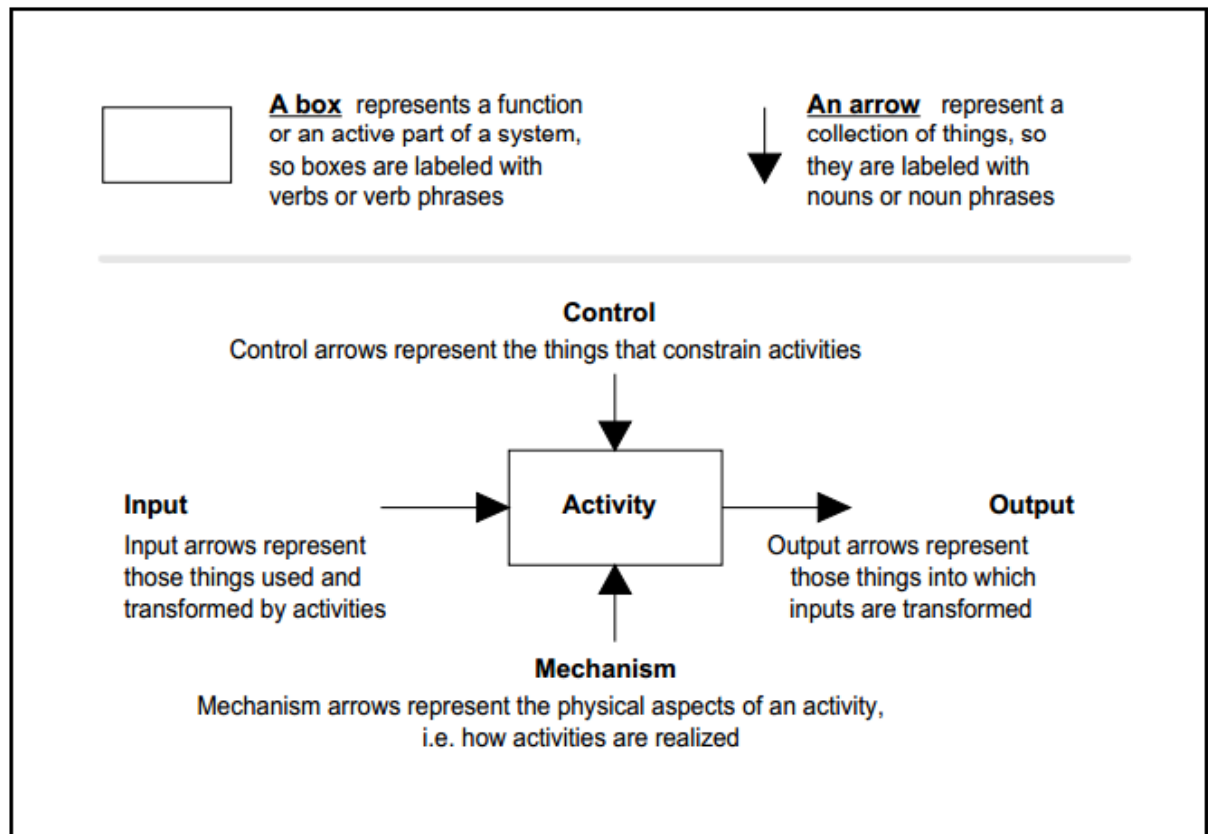


Figure 4.3: Basic Concept of IDEFØ

IDEFØ relates to strategy and business process redesigns where; (i) it provides a means of integrating core business processes with business strategy; (ii) it provides a means of integrating business processes with their information usage and information technology requirements; and (iii) it provides a means for defining current, future and alternate business processes (Viewpoint UK, 2004).

IDEFØ models help to organise the analysis of a process at all levels of detail. Models can describe the entire business at an enterprise-wide level as well as break each area down into detailed activities. The designs of the high level and detailed level can be fully integrated.

This methodology has been widely used in construction process modelling. Sanvido *et al.* (1990) used IDEFØ to develop an integrated building process model that provides open information architecture to support the provisions of a facility. Zhong *et al.* (2004) also used the same methodology to model the construction process throughout the design and construction phases. Karhu *et al.* (1997) have developed a process model for Finnish design and construction practices using IDEFØ.

#### **4.5.3 Business Process Model and Notation (BPMN)**

IDEF modelling and Business Process Modeling Notation (BPMN) are two common methods used for BIM-related business process modelling (Smith and Tardif, 2012). However, BPMN appears to be more popular nowadays and to date, BuildingSMART International, the buildingSMART Alliance, and the U.S. national BIM Standard committee have standardized on the use of BPMN.

The Object Management Group (OMG, 2011) has developed a standard BPMN. The primary goal of BPMN is to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes. Thus, BPMN creates a standardized bridge for the gap between business process design and process implementation.

BPMN is the de-facto standard for process modelling (OMG, 2011). It provides support for modelling control flow, data flow and resource allocation. BPMN is an excellent way to map out flows and process relationships to help document and communicate how a process is performed or should be performed.

A model developed with the BPMN modelling tool is easily understandable for both business and IT professionals. It can automatically generate codes that can be used directly by IT professionals to develop applications (OMG, 2011). Moreover, the development of BPMN is an important step in reducing the fragmentation that exists among process modelling tools and notations (White, 2004), such as DFD and IDEFØ as described in the previous sections.

BPMN uses a small set of notation categories to develop business process models and is powerful enough to express the complexity inherent in business processes. The categories of elements are illustrated in Figure 4.4. The four basic categories of elements are as follows (White, 2004):

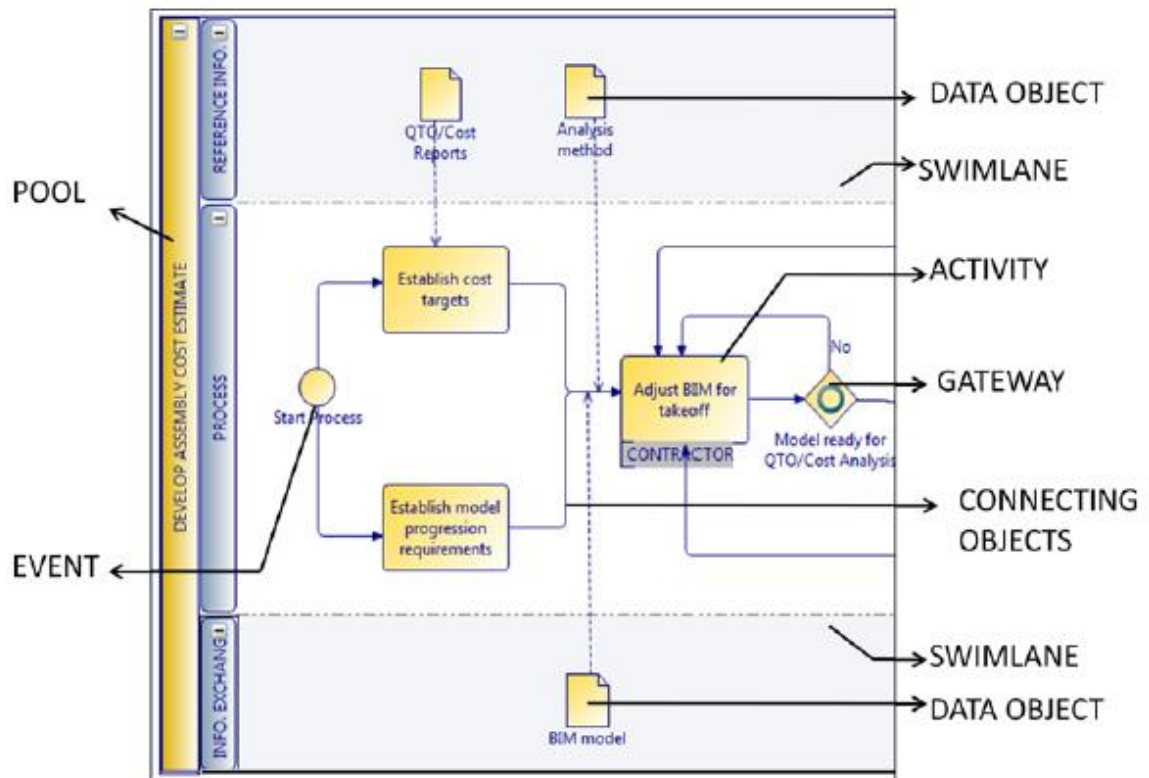


Figure 4.4: Business Process Model and Notation (BPMN) (Saluja, 2009, p. 47)

### 1) Flow Objects

There are three *Flow objects* including *Event* which is represented by a circle and is something that “happens” during the course of a business process; *Activity* represented by a rounded-corner rectangle; and *Gateway* represented by the familiar diamond shape.

### 2) Connecting Objects

The *Flow Objects* are connected together in a diagram to create the basic skeletal structure of a business process. There are three *Connecting Objects* that provide this function including *Sequence Flow* represented by a solid line with a solid arrowhead, *Message Flow* represented by a dashed line with an open arrowhead and *Association* represented by a dotted line with a line arrowhead

### 3) *Swimlanes*

Many process modeling methodologies utilize the concept of *swimlanes* as a mechanism to organise activities into separate visual categories in order to illustrate different functional capabilities or responsibilities. BPMN supports *swimlanes* with two main constructs including a *Pool* which represents a Participant in a Process. It also acts as a graphical container for partitioning a set of activities from other *Pools* and a *Lane* which represents a sub-partition within a *Pool* and will extend the entire length of it, either vertically or horizontally. *Lanes* are used to organise and categorize activities.

### 4) *Artifacts*

BPMN was designed to allow modelers and modeling tools some flexibility in extending basic notation and in providing additional context appropriate to a specific modeling situation. Any number of *Artifacts* can be added to a diagram as appropriate for the context of the business processes being modeled. *Data Objects* are a mechanism to show how data is required or produced by activities. BPMN specification pre-defines only three types of *Artifact*. They are connected to activities through *Associations*. A *Group* is represented by a rounded corner rectangle drawn with a dashed line. The grouping can be used for documentation or analysis purposes, but does not affect the Sequence Flow. *Annotations* are a mechanism for a modeler to provide additional text information for the reader of a BPMN Diagram.

Most BIM process mapping is developed using BPMN modeling tools. The reasons for adopting this approach over others such as IDEFØ are (Saluja, 2009) summarized below as:

- i. BPMN provides businesses with the capability of defining and understanding their internal and external business procedures through a Business Process Diagram. This also gives organizations the ability to communicate these procedures in a standard manner. It is a standard maintained by the Object Management Group (OMG) with a richer set of capabilities for modeling business process than IDEFØ (Wix and Karlshoej, 2010);

- ii. It has a better capability to express a business process. In particular, it uses 'swimlanes' to enable communication between actors to be visualized. This is not easy to do with IDEFØ but is critical to seeing where exchange requirements are needed in IDM (Wix, 2007);
- iii. The notation has a conversion method to the Business Process Execution Language for Web Services which is emerging as a standard XML based approach for workflow control (Wix, 2007); and
- iv. There is a possibility to better integrate with the detailed information exchange mapping initiatives used in the IDMs which are currently being developed for the National BIM Standard (NBIMS) as well as BIM Standards in other countries.

## **4.6 The Process Protocol (PP)**

Every project can be divided into discrete phases each of which has its purpose, duration and scope of work. The end of every phase is a decision point where past progress is revised and all key decisions made for the continuation of the project. Thus, the division of the project into phases, i.e. the plan of work, is an important part of every process (Zerjav and Ceric, 2009).

There are a several different stages of development of construction related “process protocols” over the past few decades that have been introduced such as the RIBA Plan of Work (RIBA, 2013), the British Property Federation (BPF) Manual (BPF, 1983) and the University of Salford’s Generic Design and Construction Process Protocol (Kagioglou *et al.*, 1998b). The RIBA Plan of Work has been highlighted earlier in section 3.6 where the project progresses from “Strategic Definition” to “In Use”, i.e. from stages 0 to 7 in a liner fashion requiring the completion of one stage before proceeding to the next. The BPF protocol, on the other hand, was intended for use by all those involved in the construction project i.e. client, design consultants, contractors, sub-contractors and suppliers. It highlights the formal and informal relationships between these parties and provides the client with value for money from the construction process. The protocol divides the design and construction process into five stages, i.e. concept, preparation of the brief, design development, tender

documentation plus tendering and construction. In this protocol, the client makes a decision at the end of each stage whether to continue with the project (Nelson *et al.*, 1999).

#### **4.6.1 The Generic Design and Construction Process Protocol**

This approach was developed as the result of a research project at the University of Salford, (UK) in cooperation with several companies that were in various ways connected to the construction industry (Kagioglou *et al.*, 1998b). The main objectives of the project were to develop a design and construction process protocol based on NPD and to examine how IT can facilitate such a process (Kagioglou *et al.*, 1998a). Recognising the importance of client involvement and support in the construction industry, client perspectives have been considered in the development of this process protocol. The processes proposed, moreover, are generic so that they can be applied in a variety of situations and by a variety of clients.

The University of Salford's process protocol is defined as "a common set of definitions, documentation and procedures that will provide the basics to allow a wide range of organisations involved in a construction project to work together seamlessly". In addition it aims "to map the entire project process from the client's recognition of a new, or emerging need, through to operations and maintenance" (Kagioglou *et al.*, 1998b). The intention was for construction firms to take the map and to use it as a framework to help them to improve their business.

Besides other modelling tools which have been discussed earlier, this process protocol is also used as a modelling tool capable of representing all diverse parties interested in a process, the flexibility and clarity of which allows generic activities to be represented in framework which encompasses standardisation. This framework encourages users to appreciate processes more easily; affording improvements in communication and co-ordination, the control and management of resources and the adoption of a 'shared vision'. By encompassing change management precepts, it allows components of a process to be separated in key phases, based on five key principles. These include: progressive design fixity; consistent process; co-ordination; stakeholder involvement/teamwork; and feedback (Goulding and Alshawi, 1999).



This process protocol was developed based on the recommendation by Rosenau *et al.* (1996), which cited it as an effective way to show how a process works:

*“A process map consists of an X and a Y axis, which show process sequence (or time) and process participants, respectively. The horizontal X axis illustrates time in process and the individual process activities (and) or gates. The Y axis shows the departments or functions participating in the process...”*

As a result, the process protocol has employed such a method by representing the project/process phases on the X-axis, and the project participants on the Y-axis. The following sections will further discuss the development of the University of Salford's Generic Design and Construction Process Protocol.

#### **4.6.2 Key Principles and Advantages of Process Protocol**

The concept of the Process Protocol was based on a number of issues and deficiencies of current practices in the construction industry. This enabled the identification of areas for improvement by examining and comparing best practices in manufacturing project processes (Kagioglou *et al.*, 2000).

The key principles of the Process Protocol are as follows (Aouad *et al.*, 1998; Cooper *et al.*, 1998; Kagioglou *et al.*, 1998a; Sheath *et al.*, 1996)

- i. It takes a whole project view to cover the whole 'life' of the project from setting up the strategy to the operation and maintenance of the project.
- ii. It adopts the “stage-gate” approach used in the NPD processes. Each process at every phase will be reviewed and validated before the next phases proceed.
- iii. It recognizes the interdependency of activities throughout the duration of projects.
- iv. It involves all stakeholders in each activity of every phase and ensures they receive the right information at the right time. The identification and prioritisation of stakeholders and their needs will enable effective decision-making throughout the project life-cycle.

- v. It encourages the establishment of multi-function teams in the early stages of the construction process whereby the need for effective co-ordination between the project team members is paramount.
- vi. It has the ability to give feedback from each phase which means that the success and failure of each phase can be recorded, updated and used throughout the process, thereby informing later phases and future projects.

Kagioglou *et al.* (1998a) have highlighted the advantages of process protocol as follow:-

- i. Process protocol has the ability to effectively translate the strategic to the operational level by examining the sub-processes and produce generic maps for those sub-processes.
- ii. Integrates IT modeling in the process where it serves as a catalyst which will result in a more consistent and improved process.
- iii. A unifying process protocol potentially capable of unifying the design and construction process.
- iv. Process protocol allows the concept of a collaborative environment by viewing whole projects throughout their life-cycle.
- v. The process protocol “stage-gate” approach dictates that collaborative processes are made, validated and finalized before the next phases can proceed.
- vi. The process protocol feedback approach allows collaborative decision making and control which will improve each phase’s output not only for the current project but also for the future projects
- vii. The IPD concept requires the early participation of all stakeholders throughout the project life-cycle. Process protocol principles allow the IPD concept to be presented and implemented.

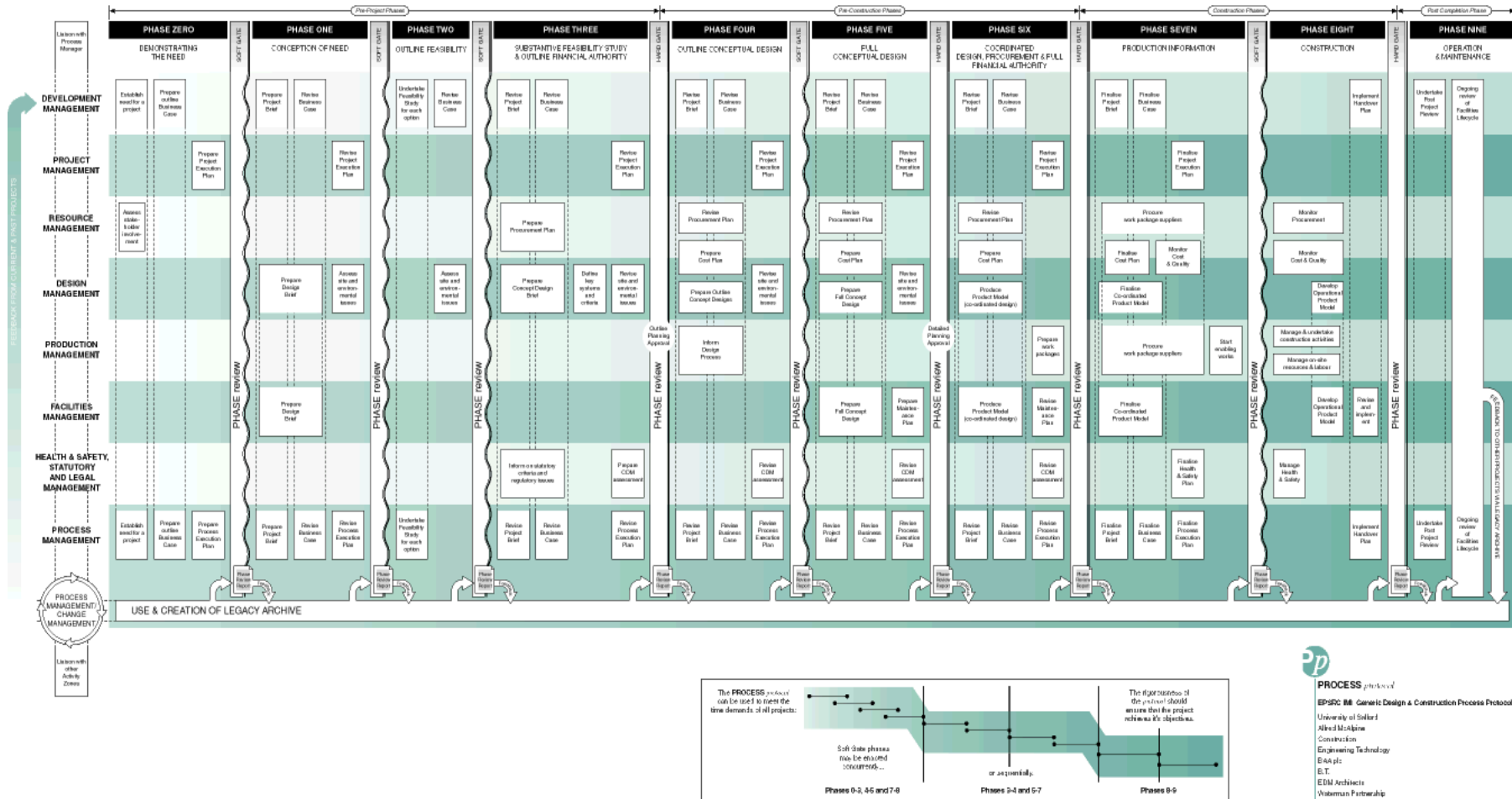


Figure 4.5: The Process Protocol Map (Kagioglou *et al.*, 1998a)

### **4.6.3 Process Protocol Phases**

The process protocol map (Kagioglou *et al.*, 1998a) divides the construction process into 4 stages that comprise of 10 phases as follow and as shown in Figure 4.5:

- ✓ Stage 1: Pre-Project Stage
- ✓ Stage 2: Pre-Construction Stage
- ✓ Stage 3: Construction Stage
- ✓ Stage 4: Post-Construction Stage

#### **Stage 1: Pre-Project Stage:**

The pre-project stage is geared to researching or investigating all the project solutions that will best satisfy the client's needs, and ensuring the outline financial authority to proceed for those solutions. It contains phases 0, 1, 2 and 3:

- ✓ Phase 0 : Demonstrating the Need
- ✓ Phase 1: Conception of Need
- ✓ Phase2 : Outline Feasibility
- ✓ Phase3 : Substantive Feasibility Study and Outline Financial Authority

#### **Stage 2: Pre-Construction Stage:**

The pre-construction stage turns the client's needs into the appropriate project on various levels of completion and ensures full financial authority to proceed. It contains phases 4, 5 and 6:

- ✓ Phase 4: Outline Conceptual Design
- ✓ Phase 5: Full Conceptual Design
- ✓ Phase 6: Coordinated Design, Procurement and Full Financial Authority

### **Stage 3: Construction Stage:**

The construction stage is that of executing the structure, i.e. it produces the project solution. It contains phases 7 and 8:

- ✓ Phase 7: Production Management
- ✓ Phase 8: Construction

### **Stage 4: Post-Construction Stage:**

The post-construction stage has the purpose of managing structure maintenance. It contains phase 9:

- ✓ Phase 9 : Operation and Maintenance

The stage/gate, or phase review, approach to process management practised in the manufacturing industry was utilised for decision-making purposes. Each stage/gate has a number of criteria and assessment factors that need to be satisfied in order to proceed to the next stage/gate. These factors or assessment criteria can be presented as deliverables of each phase. The stage/gate approach makes decision-points explicit and transparent to all stakeholders.

#### **4.6.4 Process Protocol Limitations**

The generic design and construction process protocol map was successfully developed where construction firms can take the map and use it as a framework to help them to improve their business through industry interest and acceptance. Besides the effective implementation of the process protocol, it greatly depends on its ability to effectively translate strategic objectives to the operational level. The process protocols are principally developed using a top-down approach (Anjard, 1998) with the early intension of the client to take a lead. This front-end process focused approach might lead to problems as Fisher (2002) argued that “a lot of initiatives fail because they are just front-end systems”. There is a need to enhance the protocol in terms of integrating participants at the operational level. Fleming and Koppelman (1996) investigated the integration of project development teams and found that “membership

on a project team requires cooperation from each member and respect for other functions represented on the team". Therefore, the integration of project participants, i.e. the collaboration is an essential ingredient that needs to be included within the process protocol.

The success of the implementation of the process protocol is still being hindered by the lack of new contractual arrangements. It could improve the requirements capture phase for the clients, thus allowing them to make their early stage decisions on construction or alternative project solutions (Kagioglou *et al.*, 1998a).

There is also a demand for a range of support tools that are needed by the various organisations, which will be operating the process protocol. Training is needed in order to allow the industry to establish their process capability and prioritise changes in process capability. As well as to allow them to identify and integrate an existing IT support change in the process (Kagioglou *et al.*, 1998c). Implementing the process protocol would be a matter of business re-engineering as well as process re-engineering. It will be required to be operationable across the depth of the industry as well as its breadth, in co-ordination with clients and those parties involved in the use and management of buildings beyond their completion.

Although the process protocol has been further extended to identify the sub-processes, the implementation of a process protocol framework has several issues such as (Wu *et al.*, 2001):

- i. Due to the complexity of the construction project, the process model will become very complicated. It is almost impossible to manage all the processes manually.
- ii. Companies might only adopt part of the process protocol model, depending on the nature of the project.
- iii. Some companies have their own working process and will be unwilling or unable to accommodate a new approach.
- iv. The individuals who are responsible for the process modeling and management of a project need detailed knowledge of the process protocol.

- v. The opportunities presented by Internet technology for organisations to improve the performance and more effectively reach the parties involved in the project is now being used and the process protocol needs to adapt to this technology.

#### **4.7 A Comparison of Process Protocol with other Techniques**

Process modelling tools such as the IDEF family were considered but were felt to be too complex for certain members of the targeted user group. The key was in the representation of the process and it was felt that none of the tools available met the project's requirements (Cheung and Bal, 1998). Therefore it was necessary to develop an original process map template (Fleming *et al.*, 2000).

It differs clearly from the approaches in its use of modelling methodology, which is based on a two dimensional tables of activities. The process protocol inspires companies to use a more disciplined approach to project management (for instance a so-called "stage gate" approach) than current practices (Björk, 2002).

The process protocol is also different from other techniques (Kagioglou *et al.*, 1998a; Kagioglou *et al.*, 1998b):

- i. Most process modeling techniques such as flowcharts, data flow diagrams (DFD), IEDFØ, etc. describe the process but did not communicate its elements effectively.
- ii. Process protocol informs all project participants of changes made as well as providing the backbone for communications through its feedback principle.
- iii. Process protocols consist of X and Y axes, which show process sequences (project phases) and process participants, respectively.
- iv. Process protocol integrates IT modeling and enables communications between project participants, as well as speeding up the development of a project solution.

## **4.8 Process Protocol and Client Organisations**

Kagioglou *et al.* (1998a) highlighted that there was clearly a need for an earlier and full involvement of design construction professionals in the pre-project advisory stage, where clients would be deciding upon construction as one of the many possible options to improve their facilities. At this phase, it was clearly articulated by the participating industrials and the clients that a lack of consultation opportunities exist between the industry and client bodies.

The generic process protocol, which allows or facilitates the development of virtual teams and the co-ordination of a series of investigative activities in the pre-project phase, would clearly be a potential vehicle for achieving requirements that capture the client's needs. Although the process protocol was designed specifically to operate at the strategic management level, the industrial group has proposed that the consistent process would provide a very strong facilitating platform to allow systematic improvement in the operational processes. This would benefit and transform the client's organisations to be more effective (Kagioglou *et al.*, 1998a).

The phase review introduced in the process protocol allows the progress of each phase to be assessed and to adjudicate on the continuation of the process and the project. In this case, it will automatically bring together all the stakeholders such as clients, designers and contractors in a co-ordinated manner Kagioglou *et al.* (1998b). This also allows other stakeholders to get involved at the early stages thus in-line with the concept of BIM and IPD implementation.

## **4.9 Summary**

It was highlighted that the implementation of BIM is causing the construction industry to cast a critical eye on other business processes and ask how these can be reorganised in a structured way. The business process management depends on the concept of process modelling which is a tool that provides a means of communicating complex business functions in a form more understandable by people. Process modelling can play a vital role in improving the construction industry by underpinning the application of BIM and IPD.



The University of Salford's process protocol, which will be adopted by this study, has been investigated in this chapter. This is mainly because it was found to be the most relevant and comprehensive method in the field of process management and has great relevance to the aim of the study. The six key principles of the process protocol were outlined and the issues which hindered the early development of process protocol were discussed. The following chapter will discuss the research methodology that will be used to achieve the aims and objectives of the study.

# CHAPTER 5

## Research Methodology

### 5.1 Introduction

Research is a process of steps used to collect and analyse information to increase our understanding of a topic or issue. It consists of three steps: Pose a question, collect data to answer the question, and present an answer to the question (Creswell, 2002). Research also is a continuous process of careful and systematic investigation into a field of knowledge using appropriate and accepted scientific methods to gather factual material to solve identified problems, establish facts or define principles so as to establish reliable and valid knowledge about a phenomenon (Naoum, 2012). In short, research is a combination of both experience and reasoning and must be regarded as the most successful approach to the discovery of truth (Cohen *et al.*, 2013).

The most important aspect of a research is the clarity of the research problem. After having performed the preliminary study and demarcated the problem, the research problem or statement can be drawn. The definition of the problem stage in the research process is an extremely important one. Without a properly defined problem the research cannot progress. One cannot design a research plan without a very clear idea of what needs to be accomplished (Strangman, 2013).

Methodology provides the procedural framework within which the research is carried out and a way to systematically solve the research problem (Remenyi *et al.*, 1998). The procedures and processes applied to such an investigation are defined in the research methodology (Clarke, 2000). It aims is to give the work a plan of research. The Industrial Research Institute (2010) defines research methodology as a way to find out the result of a given problem on a specific matter that is also referred to as the research problem. In research methodology, researchers use different criteria for solving/searching the given research problem. Different sources use different type of

methods for solving the problem. Research methods or techniques, on the other hand are the various procedures, schemes, algorithms, etc. used in research which include theoretical procedures and approaches etc. Research methods help with collecting samples, data and to find a solution to a problem. Particularly, scientific research methods call for explanations based on collected facts, measurements and observations and not on reasoning alone (Rajasekar *et al.*, 2006).

Walker (1997) stated that the choice of a research methodology is a difficult step in the research process. As such many researchers struggle with the confusing questions of how to choose an appropriate methodology for the research question they are attempting to investigate.

It is the purpose of this chapter to address and highlight the research methodology principles that will be utilised in this particular research study. This will include the qualitative and quantitative approaches, case studies and the semi-structures interviews for data collection. The research methodology used in this research study is also outlined.

## **5.2 The Qualitative and Quantitative Approach**

Research may be categorised into two distinct types: qualitative and quantitative. The emphasis of qualitative research is more subjective in nature than quantitative research and involves examining and reflecting on the less tangible aspects of a research subject, e.g. values, attitudes, perceptions (Neville, 2007). Although this type of research can be easier to begin, it can often be difficult to interpret and present the findings: the findings can also be challenged more easily. It focuses on exploring issues and themes on a subject matter in detail emphasising more depth than breadth (Blaxter *et al.*, 2010).

Contrastingly, quantitative research entails collecting and analysing numerical data. It concentrates on measuring the scale, range, frequency etc. of phenomena (Neville, 2007). It is applicable to phenomena that can be expressed in terms of quantity. This type of research, although harder to design initially, is usually highly detailed and structured and results can be easily collated and presented statistically. Numerical data is collected and analysed as statistically measurable variables to obtain results

which can be used to determine the validity or otherwise of a hypothesis (Blaxter *et al.*, 2010). Table 5.1 outlines the differences between the two strands of research.

Table 5.1: The Differences between Qualitative and Quantitative Research (Kumar, 2005)

	Difference with respect to	Qualitative Research	Quantitative Research
1	Underpinning philosophy	Empiricist	Rationalist
2	Approach to inquiry	Unstructured/semi-structured or open methodology	Structured/predetermined methodology
3	Main purpose of investigation	To describe variations in a phenomenon or situation	To quantify the extent of variation in a phenomenon or situation
4	Main purpose of investigation	Emphasis on description of variables	Emphasis on some form of measurement or classification of variables
5	Sample Size	Fewer Cases	Emphasis on greater sample size
6	Focus of Inquiry	Covers multiple issues but assembles required information from fewer respondents	Narrows focus in terms of extent of inquiry, but assembles required information from a greater number of respondents
7	Dominant Research Value	Authenticity but does not claim to be value-free	Reliability and objectivity
8	Dominant Research Topic	Explores experiences, meanings and perceptions	Explains prevalence, incidence, extent, discovers regularities and formulates theories
9	Analysis of Data	Subjects responses or observation data to identification of themes and describes these	Subjects variables to frequency distributions, cross tabulations or other statistical procedures
10	Communication of Findings	Organisation more narrative in nature	Organisation more analytical in nature, drawing inferences and conclusions and testing the magnitude and strength of a relationship

There is always confusion over the choice between qualitative and quantitative data for a research project. This is due to the fact that most research on the construction industry is related with quantitative research (Adejimi *et al.*, 2011). It is apparent that both qualitative and quantitative methods involve different strengths and weaknesses. The combination of methodologies, on the other hand, can focus on their relevant strengths.

When qualitative research is used along with quantitative methods, qualitative research can help researchers to interpret and better understand the complex reality of a given situation and the implications of quantitative data. Triangulation or a multi-method approach refers to the technique of integrating qualitative and quantitative data collection and analysis methods into one framework. The main reason for using triangulation is that measurement improves when diverse indicators are used. Having different measurements of a variable from diverse methods implies greater validity. Also, in a single research project, measuring different variables might require the use of different methods (Neuman, 1997; Sekaran, 1984).

### **5.3 Case Study as Research Method**

Research strategy is one of the components of research methodology. Research strategy provides an overall direction of the research including the process by which the research is conducted (Remenyi *et al.*, 1998). Case study is one of such research strategies. Case study research is defined as a research strategy which focuses on understanding the dynamics present within single settings (Eisenhardt, 1989). It allows the exploration and understanding of complex issues. It can be considered a robust research method particularly when a holistic, in-depth investigation is required. By including both qualitative and quantitative data, case study helps explain both the processes and outcomes of a phenomenon through complete observation, reconstruction and analysis of the cases under investigation (Tellis, 1997). Yin (2009) defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.

It can be seen that case study research is capable of accommodating different research techniques and is normally used when it is required to obtain in-depth knowledge with regards to a particular phenomenon. One or several cases can be used to reach specific or general conclusions about certain phenomena (Gummesson, 2003). Cross-case analysis with a case-survey or case-comparison approach can be applied when using several cases (Yin, 1981).

Walliman and Bousmaha (2001) stressed the issues related to division of a problem to which the answer can be only “yes” or “no”. Indeed they argue that a yes–no solution to a problem skirts the issues by avoiding the search for the reasons why yes or no is the answer and the implications which the answer contains. Case study is preferred when the research questions take the form of “how” and “why”. This is supported by Yin (2009), as case study research is the appropriate type of research to be used when the research questions are ‘how’ and ‘why’ types of questions and no control over behavioural events is possible or desired along with a focus on contemporary issues.

The researcher, when using case study, should investigate the research problem through the eyes of the subjects being investigated which could be based on a predefined model (Leidner and Jarvenpaa, 1993). Case study research provides the researcher with a fascinating input of real-life data from which concepts can be formed and theory can be tried (Gummesson, 2003). The Case study research approach is especially appropriate in new topic areas (Eisenhardt, 1989; Irani *et al.*, 1999) and can be used for both theory testing (Cavaye, 1996; Irani *et al.*, 1999) and theory generation (Gersick, 1988).

Case studies usually combine multiple data collection methods such as archives, interviews, questionnaires and observations. Even though case studies are typically associated with qualitative data, the collected data may, in fact, be either quantitative, qualitative, or both (Eisenhardt, 1989).

### **5.3.1 Case Study Categorisation**

Yin (2009) noted three categories of case studies, i.e. exploratory, descriptive and explanatory. Details of these categories are as follows:

- Exploratory - It involves exploration of any phenomenon in the data. In this case study, a pilot has been conducted as the control case to examine the proposed protocol of the study. A pilot study is considered an example of an exploratory case study (McDonough and McDonough, 1997; Yin, 2009) and is important in determining the protocol that will be used.
- Descriptive - It is used to describe the natural phenomenon which occurs within the data in question. For instance, the different strategies used by readers and how the readers use them. An example of a descriptive case study is the journalistic description of the Watergate scandal by two reporters (Yin, 2009). The challenge of a descriptive case study is that the researcher must begin with a descriptive theory to support the description of the phenomenon or story. If this fails, there is a possibility that the description lacks rigour and that problems may occur during the project.
- Explanatory - It is used to examine the data closely both at a surface level and at a deeper level in order to explain the phenomena in the data. On the basis of the data, the researcher may then form a theory and set out to test this theory (McDonough and McDonough, 1997). Furthermore, explanatory cases are also deployed for causal studies where pattern-matching can be used to investigate certain phenomena in very complex and multivariate cases.

This researcher is keen on explorative case studies which will be designed to explore a phenomenon with the aim to develop an initial process roadmap for the successful implementation of IPD at Client organisations using BIM as the main vehicle to control and manage the integration process.

### **5.3.2 Advantages of Case Study Methodology**

Case study has a number of advantages as follows:

1. The examination of the data is most often conducted within the context of its use (Yin, 2009), that is, within the situation in which the activity takes place. A case study might be interested, for example, in the process by which a subject comprehends an authentic text. To explore the strategies that the reader uses, the researcher must observe the subject within their environment. This would contrast with experiments, for instance, which deliberately isolate a phenomenon from its context, focusing on a limited number of variables (Zainal, 2007).
2. Variations in terms of intrinsic, instrumental and collective approaches to case studies allow for both quantitative and qualitative analyses of the data. Some longitudinal studies of individual subjects, for instance, rely on qualitative data from journal writings which give descriptive accounts of behaviour. On the other hand, there are also a number of case studies which seek evidence from both numerical and categorical responses of individual subjects such as in Block (1986) and Hosenfeld (1984). While Yin (2009) cautions researchers not to confuse case studies with qualitative research, he also notes that case studies can be based entirely on quantitative evidence.
3. The detailed qualitative accounts often produced in case studies not only help to explore or describe the data in a real-life environment, but also help to explain the complexities of real-life situations which may not be captured through experimental or survey research. A case study of reading strategies used by an individual subject, for instance, can give access to not only the numerical information concerning the strategies used, but also the reasons for strategy use, and how the strategies are used in relation to others (Zainal, 2007).

As discussed above, the advantages of adopting the case study method were suited well with the aims and objectives of this study.



### **5.3.3 Disadvantages of Case Study Methodology**

Despite these advantages, case studies have received criticisms. Yin (2009) discusses three types of arguments against case study research as follows:

1. Case studies are often accused of a lack of rigour. Yin (2009, p. 14) notes that too many times, the case study investigator has been sloppy, and has allowed equivocal evidence or biased views to influence the direction of the findings and conclusions.
2. Case studies provide very little basis for scientific generalisation since they use a small number of subjects, some are even conducted with only one subject.
3. Case studies are often critiqued as being too long, difficult to conduct and producing a massive amount of documentation Yin (2009). In particular, case studies of an ethnographic or a longitudinal nature can elicit a great deal of data over a period of time. The danger comes when the data is not managed and organised systematically.

A common criticism of the case study method is its dependency on a single case exploration making it difficult to reach a generalising conclusion (Tellis, 1997). Yin (1994) considered case study methodology as microscopic because of the limited sampling cases. To Hamel *et al.* (1993) and Yin (1994), however, parameter establishment and the objective setting of the research are far more important in the case study method than a big sample size.

The disadvantages of the case study have been mitigated which drawn the scope and limitation of this research by adopting a better case study strategy and managing the information more effectively.

### **5.3.4 The Selection of Case Study as the Research Method**

Fellows and Liu (2009) suggested that specifically for construction, there are five methods that can be considered. These are action research, ethnographic research, surveys, case studies, and experiments. The critical consideration is the logic that links the data collection and analysis to yield results and therefore conclusions to the

main research question being investigated. Furthermore, selecting the most appropriate research approach to achieve the research aim depends on the specific research questions. As Neuman (1997) explains: *“it takes skill, practice, and creativity to match a research question to an appropriate data collection technique”*.

Balian (1982), Sproull (2002), and Neuman (1997) suggested some reference points for use when making the choice of research approach in order to answer a research question:

- i. Determine what type of data is required (opinions, attitudes, perceptions, hard data, etc.)
- ii. Determine the depth or generalisation needed.
- iii. Determine what resources are available (time, money, etc.)
- iv. Determine the degree of control and ability to manipulate variables.

Table 5.2: Justification for Selecting Research Method (Yin, 2009, p. 8)

<b>METHOD</b>	<b>Form of Research Question</b>	<b>Requires Control of Behavioural Events</b>	<b>Focuses on Contemporary Events</b>
Experiment	How and why?	Yes	Yes
Survey	Who, what, where, how many and how much?	No	Yes
Archival Analysis	Who, what, where, how many and how much?	No	Yes/No
History	How and why?	No	No
Case Study	How and why?	No	Yes

Creswell (2003) on the other hand, suggested that the research design must take into account the research questions, determine what data is required and how the data is to be analysed. As the research is positioned within a qualitative approach based on the research questions posed, the options that were available are action research, ethnographic research, and case studies. Since this research is more reliant on the process and current phenomenon, case study has been opted as the research methodology for the exploration research. The exploration study in this research also

focuses on the depth of study rather than breadth, examining a particular process, which exists in natural settings and requires multiple sources of evidence. Exploratory case study research concerns a phenomenon in its situational context, as suggested by Brotherton (2008).

Yin (2009) provides a guide on selecting the research method as shown in Table 5.2. The selection of case study as the research method was further strengthened by the following justifications:

*i. The type of research question posed*

As discussed previously in the research approach, this research poses the question of “how” and “what” and in an exploratory way. The questions posed deal with operational links needing to be traced over time rather than mere frequencies or incidences (Yin, 2009). The aim is to develop a process roadmap based on theoretical protocol, which it will be explored and modified once the data has been collected.

*ii. The extent of control an investigator has over actual behavioural events*

Describes the degree to which the researcher can manipulate the behaviour of the subject, for example by giving or withholding motivators (Yin, 2009). Within this context, the options available were reduced to histories and case studies since the researcher has no control on the acceptance and the condition of respondents during data collection or the maturity of the respondents.

*iii. Focuses on contemporary events*

In this justification, the only difference between history and case study is that histories are dealing with data of the past where no relevant persons are alive to report, even retrospectively, what occurred (Yin, 2009). Therefore it requires an investigator to rely on primary documents, secondary documents, and cultural and physical artifacts as the main sources of evidence. Case studies, on the other hand, besides utilising the same evidence, add two more sources of evidence: direct observation of the events and interviews with the persons involved in the events. Therefore, it justifies the need of selecting case studies

as the research method for data collection as the researcher has managed to utilise the two sources of evidences.

In addition, Saleh and Alshawi (2005) suggested that a case study is the most appropriate investigation method for determining the criteria for a readiness assessment model of ICT implementation as compared to the survey. The case study is an important instrument to the investigation process and understanding the current phenomenon. One of the strengths of the case study approach is that it allows the researcher to use a variety of sources and a variety of data types. A survey, on the other hand, can only give the measurement of quantity (how much) on certain data which may not be appropriate for an exploration study. In addition, Benbasat *et al.* (1987) consider a case study approach to be appropriate for new research areas and where respondents are of crucial importance to the study.

### **5.3.5 The Development of Process Protocol**

Generic design and construction process protocol were developed by the research team at the University of Salford (Kagioglou *et al.*, 1998b). They adopted the use of multiple research methods. This research strategy is well-known as triangulation, which attempts to exploit the strengths and offset, rather than compound, the weakness of different methodologies. It has been demonstrated through the development of the case studies.

The exploratory case studies above were undertaken with the aim to establish what activities had occurred and what significant variables and relations were at work. From the prediction, the understanding gained from the exploratory dimension was later used to test the hypotheses.

This case study approach has been criticised due to its lack of measurability as the data gathered is generally based on perceptions and subjective interpretations of the individual researchers. Therefore making the quantification and manageability of the findings problematic and ambiguous. In response to this methodological weakness, more in-depth data collections have been carried out through interviews, questionnaires and verification of the findings in workshops (Kagioglou *et al.*, 1998a).

In order to strengthen the findings of the process protocol, a numbers of interviews were carried out through case study investigation throughout the research process. The semi-structured interviews were used to allow the interview to have an overall purpose, but sufficiently flexible to explore the relevant issues that arose. Finally, the contents of interviews were validated by case study reports, which were given to the relevant industrial partners for comment and recommendation.

### **5.3.6 The Case Study Design**

As mentioned in the previous section, the case study method has received criticism for its lack of robustness as a research tool. Therefore crafting the design of case studies is of paramount importance. Researchers can adopt either a single case or multiple case designs depending on the issue in question. In cases where there are no other cases available for replication, the researcher can adopt the single case design. However, the drawback of a single-case design is its inability to provide a generalising conclusion, in particular when the events are rare. One way of overcoming this is by triangulating the study with other methods in order to confirm the validity of the process. The multiple-case design, on the other hand, can be adopted with real-life events that show numerous sources of evidence through replication rather than sampling logic. As for the number of cases, Tzortzopoulos (2004) stressed that there is no consensus in the appropriate number of cases which need to be developed when engaging in a multiple case study approach. According to Yin (2009), generalisation of results from case studies, from either single or multiple designs, stem from theory rather than populations. By replicating the case through pattern matching, a technique linking several pieces of information from the same case to some theoretical proposition (Campbell, 1975) multiple-case design enhances and supports previous results. This helps raise the level of confidence in the robustness of the method.

A multiple case design is the selection of two or more cases that are believed to be literal and theoretical replications (Yin, 2009). An Analytical conclusion independently arising from two cases will be more powerful than those coming from a single case alone. Additionally, a case study offers contrasting situations (Yin, 2009). In general, criticisms about single case studies usually reflect fears about the uniqueness or

conditions surrounding the case. Therefore, multiple case studies are more likely to weaken such criticism and scepticism. The evidence from multiple cases is often considered more compelling and robust (Yin, 2009). External validity is more difficult to attain in a single-case study. The researcher has considered this difficulty and went looking for similar relationships with all case studies to confirm and generalise the findings. The research used a multiple case to obtain findings that will help the researcher to address the aims and objectives of the study. A careful, but rigid, selection of cases is also important to ensure that sufficient information is obtained by the researcher in order to generate the final conclusions at the end of the research.

Table 5.3: Types of Case Study Evidence (Yin, 2009, p. 102)

	Source of Evidence	Strengths	Weaknesses
1	Documentation	<ul style="list-style-type: none"> <li>✓ stable - repeated review</li> <li>✓ unobtrusive - exist prior to case study</li> <li>✓ exact - names etc.</li> <li>✓ broad coverage - extended time span</li> </ul>	<ul style="list-style-type: none"> <li>✓ retrievability – difficult</li> <li>✓ biased selectivity</li> <li>✓ reporting bias – reflects author bias</li> <li>✓ access - may be blocked</li> </ul>
2	Archival Records	<ul style="list-style-type: none"> <li>✓ same as above</li> <li>✓ precise and quantitative</li> </ul>	<ul style="list-style-type: none"> <li>✓ same as above</li> <li>✓ privacy might inhibit access</li> </ul>
3	Interviews	<ul style="list-style-type: none"> <li>✓ targeted - focuses on case study topic</li> <li>✓ insightful - provides perceived causal inferences</li> </ul>	<ul style="list-style-type: none"> <li>✓ bias due to poor questions</li> <li>✓ response bias</li> <li>✓ incomplete recollection</li> <li>✓ reflexivity - interviewee expresses what interviewer wants to hear</li> </ul>
4	Direct Observations	<ul style="list-style-type: none"> <li>✓ reality - covers events in real time</li> <li>✓ contextual - covers event context</li> </ul>	<ul style="list-style-type: none"> <li>✓ time-consuming</li> <li>✓ selectivity - might miss facts</li> <li>✓ reflexivity - observer's presence might cause change</li> <li>✓ cost - observers need time</li> </ul>
5	Participant Observations	<ul style="list-style-type: none"> <li>✓ same as above</li> <li>✓ insightful into interpersonal behaviour</li> </ul>	<ul style="list-style-type: none"> <li>✓ same as above</li> <li>✓ bias due to investigator's actions</li> </ul>
6	Physical Artefacts	<ul style="list-style-type: none"> <li>✓ insightful into cultural features</li> <li>✓ insightful into technical operations</li> </ul>	<ul style="list-style-type: none"> <li>✓ selectivity</li> <li>✓ availability</li> </ul>

## **5.4 Data Collection and Analysis Methods**

Data collection means gathering information to address those critical evaluative questions that have been identified earlier. In collecting the data for the research, Yin (2009) identified six primary sources of evidence. Their strengths and weaknesses, which can be used for case studies, are shown in Table 5.3. These sources of evidence have initially provided the checklist for this research regarding sources of information to be collected. According to Stake (1995) and Yin (2009), not all sources are essential in every case study but the importance of having multiple sources of data lays the foundations of the reliability for the study.

There are many methods and sources available to gather information. The most important issue related to data collection is selecting the most appropriate information or evidence to answer the questions. Qualitative research typically relies on four methods for gathering information, i.e. (a) participating in the setting, (b) observing directly, (c) interviewing in depth, and (d) analysing documents and materials.

Three types of data collections have been utilised in this research, (a) an extensive literature review, (b) questionnaires, and (c) interviews.

### **5.4.1 Literature Review**

A literature review is an un-intrusive secondary method of data collection involving an extensive review of related research publications on a defined subject matter (Denscombe, 2010; Moore, 2000). Such a review provides preliminary insights into a subject area, including the gaps inherent there, hence forming a sound basis from which further research can be carried out (Blaxter *et al.*, 2010).

A literature review serves many important purposes: including establishing the need for the research; broadening the horizons of the researcher; and preventing the researcher from conducting research that already exists. Aitchison (1998, p. 58) supports the view that a literature review allows the researcher to find out what has been done in terms of the problem being investigated - to ensure that duplication does not occur.

An extensive literature review was carried out to meet the goals of this research especially on the needs and justifications of conducting this research. This literature review was covered and discussed in detail in chapters 2, 3 and 4.

### **5.4.2 Questionnaires**

Questionnaires are one of the most widely used methods of data collection. Questionnaires are a good way to collect perception data from people (stakeholders, staff, customers etc.), particularly when there are large numbers of viewpoints to be collected. A questionnaire is a list of open (broad) or closed (concise) questions issued to respondents using various media for which appropriate answers are sought (Denscombe, 2010; Fellows and Liu, 2009). Questionnaires may be distributed in the absence of the researcher. Thomas (1996) argues that the layout, structure and language must be clear to respondents in order to be effective.

The advantages of using questionnaires are as follows: (a) they can be given to large groups, (b) the respondents can complete the questionnaire at their own convenience, (c) they can answer questions out of order, (d) they can skip questions, (e) they can take several sessions to answer the questions, and (f) they can write in comments. The cost and time involved in using questionnaires is less than with interviews. The disadvantages include the inability to probe deeply into respondents' beliefs, attitudes and inner experiences. Modifications to the questions cannot be made once the questionnaire has been distributed (663studygroup, 2006).

The key to minimizing the disadvantages of the survey questionnaire lies in the construction of the questionnaire itself. A poorly developed questionnaire contains the seeds of its own destruction. Each of the three portions of the questionnaire - the cover letter, the instructions, and the questions - must work together to have a positive impact on the success of the survey.

The questionnaire is the means for collecting the survey data. It should be designed with data collection plan in mind. Each of its three parts should take advantage of the strengths of questionnaires while minimizing their weaknesses. Each of the different kinds of questions are useful for eliciting different types of data but each should be constructed carefully with well-developed construction guidelines in mind. Properly



constructed questions and well-followed survey procedures will allow obtaining the data needed to check the hypothesis and, at the same time, minimize the chances that one of the many types of bias will invalidate the survey results.

### **5.4.3 Interviews**

The interview can be described as a communicative process through which the investigator extracts information from a person or informant. The extracted information will be strongly influenced by the respondent, who acts and interprets his environment on the basis of his previous experiences. So every interview generates a subjective informative product shaped by the interviewees' experiences. Interviews involve the questioning of a respondent through discourse on a defined theme or subject area to obtain responses aimed at addressing a research hypothesis (Kumar, 2005; Naoum, 2012).

Interviews have particular strengths: An interview yields data quickly and in a great quantity. However, interviewing has limitations and weaknesses. Interviewees may be unwilling or may be uncomfortable sharing all that the interviewer hopes to explore, or they may be unaware of recurring patterns in their lives. The major advantage of the interview is its adaptability in controlling the response situation, scheduling a mutually convenient time and place, and controlling the sequence and pacing of the questions asked. Questions can be modified as needed. Interviews can probe deeply into respondents' beliefs, attitudes and inner experiences by following up with questions to obtain more information and clarify vague statements. Interviewers can build trust and support with respondents, making it possible to obtain information that might not have been revealed using another data collection method. The limitations of interviews include difficulty in standardizing the interview situation so the interviewer doesn't influence the respondent's answers. Interviews cannot provide anonymity for the respondent, but the reporting of responses can be anonymous (663studygroup, 2006).

Interviews could be personal (face-to-face) or via a medium (internet or telephone). The richness of data collected via interviews makes the process of analysing the outputs very lengthy and difficult. The most important features of each interview approach are presented in Table 5.4.

Table 5.4: Approaches of Open-Ended Interviews (Patton, 2005)

The Informational Conversational Interview	The Interview Guide	The Standardized Open-ended Interview
Unstructured	Semi-structured	Semi-structured
<p>Questions flow from immediate context; no predetermination of questions, topic or wording</p> <p>✓ Conversational flow as a major tool of fieldwork</p>	<p>The interview guide provides topics or subject areas in advance, in an outline form</p> <p>✓ Within the framework of the guide, the interviewer is free to explore, probe, and ask questions</p> <p>✓ However: focus on a particular predetermined subject</p>	<p>The exact wording of questions and their sequence are predetermined</p> <p>✓ Each respondent gets to answer the same questions in the same way and in the same order, including standard probes</p>
Data gathered will be different for each person interviewed	Data collection more systematic	Enhanced comparability of data

All three formats have open-ended questions, meaning that the phrases or answer categories used by respondents are not predetermined, as this is the case in closed, fixed-response interviews in quantitative studies. The format that was applied in this research is that of the interview guide approach. The advantage of this approach is that it makes data collection more systematic and ensures that certain topics and issues of interest will be covered (Patton, 2005). The interview guide developed for this research mainly consists of experience and opinion questions.

Easterby-Smith *et al.* (2012) stressed that the in-depth semi-structured interview is the most fundamental of qualitative methods. The interviews allow interviewee's experiences, knowledge, ideas and impressions to be documented (Alvesson, 2003) and provide an opportunity for the researcher to uncover new clues and open up new dimensions of a problem (Yin, 2009). Robson (2002) highlighted that semi-structured interviews have predetermined questions but the order of the questions can be modified based on the interviewer's perceptions of what seems to be most appropriate. All interviews in this research had an exploratory and explanatory nature as it gave a focus to the interview, allowing the researcher to be flexible in exploring

emerging issues. The interviews questions were also kept short and brief to ease the interviewee to respond.

Table 5.5: Validity and Reliability Procedures for Case Study (Yin, 2009, p. 41)

Test	Case Study Tactics	Proposed Measures
Construct validity	<ul style="list-style-type: none"> <li>✓ Use multiple sources of evidence</li> <li>✓ Establish a chain of evidence</li> <li>✓ Have key informants review the draft report</li> </ul>	<ul style="list-style-type: none"> <li>✓ Triangulation <ul style="list-style-type: none"> <li>▪ Integrating theories</li> <li>▪ Multiple sources of evidence (documents review, survey and interview)</li> <li>▪ Integrating data analysis methods: content analysis and cognitive mapping</li> </ul> </li> </ul>
Reliability	<ul style="list-style-type: none"> <li>✓ Use case study protocol</li> <li>✓ Develop case study database</li> </ul>	<ul style="list-style-type: none"> <li>✓ Documenting procedures and steps used in the case study</li> <li>✓ Verification of transcripts consistent interview</li> </ul>

## 5.5 Validity and Reliability Issues

The potential weaknesses of case study research are a problem of accessibility, lack of rigour, sloppiness, biased views and a lack of scientific basis for statistical generalisation.. Yin (2009) highlighted two aspects of validity: internal validity and external validity. The former is concerned with the truthfulness of case study and interference and the latter is a question of generalising the findings beyond the immediate case study. On the other hand, reliability is significant for case study data and is about the errors and bias of the study. To address this problem, the research followed a case study validation strategy, as proposed by Yin (2009) and depicted in the following Table 5.5.

In the test of construct validity, the use of multiple sources of evidence can increase the level of validity. This research also relies on the use of multiple respondents to satisfy the validity requirement. Besides conducting multiple interviews as the primary source of evidence, other sources were also proposed such as documents, reports, etc. The following steps were carried out for the validation purposes:

1. The proposed process protocol is validated with the first case study, as a “control case”, with the aim to carry out an initial evaluation of the process protocol mainly to ensure that its components are valid for the local conditions in the UAE. The validation process was carried out by tracing back problems found during construction to their main causes and then to the process protocol.
2. The results from case study one was further validated by the Client Office representative with a highly qualified structural engineer with more than 30 years of experience in designing and managing large and complex projects in the UAE.
3. Case studies two and three involve on-going projects in the UAE, which have implemented BIM during the design stage and adopted collaboration as a means to improve the final design product. Both of these case studies are used to validate Phases 1-6 of the proposed process protocol. The client’s representative will validate all the phases, i.e. from phase 0 to 6.
4. The semi-structured interviews are carried out with the project stakeholders, i.e. the consultant and the contractor to evaluate and validate the proposed process protocol from the project requirement phase to the FM phase. The interviewee’s recommendations and suggestions to strengthen the protocol are taken into account.
5. Final recommendations of the overall process protocol will be drawn after the validation process.

## **5.6 Research Study Approach**

This research has adopted the case study as the overall research strategy, with multiple sources of evidences, semi-structured interviews and documentations were used for data collection. In order to have a structured research approach, it is more appropriate to present a brief overview of the research design. Research design consists of a series of actions or steps that are necessary to effectively carry out research and the desired sequencing of these steps. Figure 1.1 illustrates the research design of this study.

An extensive literature review has been carried out to explore the issues concerning the performance of the construction industry where poor integration in the supply chain and lack of strategic commitment at senior management and government levels have been dictated. New technology using BIM and IPD has been found as the best tool and delivery method for performance improvement that needs to be explored further. It became clear that problems in adapting and understanding this new technology and these delivery methods could hinder the success of their implementation.

The principles of the process protocol developed by the University of Salford, along with supporting literatures have led to the development of an initial process protocol on implementing the new concept of BIM and IPD within client organisations. The initial stages of this research highlighted a few important issues and principles to successfully implement BIM and IPD such as the roles and responsibilities of stakeholders, risks, legal frameworks, contracts and the need of a BIM/IPD strategy for client organisations. All these elements have been accommodated in the development process of the proposed process protocol. Seven project phases have been proposed for the process protocol with the focus on the provision of a strong client leadership throughout the design and construction of projects (Figure 5.1).

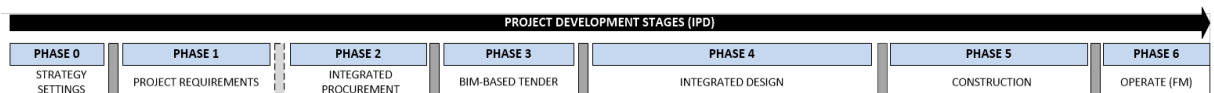


Figure 5.1: Project phases of the proposed process protocol

In this research, three case studies of typical projects in the UAE have been identified and selected as the research context. The first selected case study is a typical project which suffered from delays and cost overrun. At the time of conducting this case study, the project was facing 17 months of delays. This case study was to carry out an initial evaluation of the process protocol mainly to ensure that its components are valid for the local conditions in the UAE. The case study added further confirmation to the findings from the literature review by adding local factors to the various phases of the process protocol. Qualitative research work was conducted including semi-structured interviews with project stakeholders to discover the real reasons behind this delay. This case study has also investigated the real causes of the problems and if they can

be adequately addressed by BIM and IPD. Special focus was also placed on the client leadership and the client role to eliminate/minimize these problems.

Case study one was carried out by interviewing the main parties involved in delivering the project, including: members of the client committee, the client representative on-site, the project management company and the contractor. Information about the delays was collected from each partner individually and then analysed and categorised into a number of groups based on their significance in terms of time and cost. Each group of problems were then traced back to their main causes to identify the key actions that could be taken in the future to avoid such problems. These were then reflected into the various phases of the process protocol.

Case studies two and three involve on-going projects in the UAE, where BIM and collaboration have been used to improve the design and construction process. The aim of these cases was to validate the process protocol and its various components. These two cases are specifically selected to ensure that the proposed process protocol can handle possible variations in procurement systems, particularly in competitive tendering requirements. Semi-structured interviews were conducted with the client representatives, consultants, contractors and subcontractors. These interviews focused on validating the various components of the process protocol both during the design and construction stages. The interviews were conducted with managers to capture their views towards the process and its management as well as with technical staff (engineers, planners and quantity surveyors) to ensure that the detailed description of each process is valid and comprehensive.

Case study two has been selected because it is the first IPD delivery in the UAE where the maturity level of the local construction industry to deliver projects with an IPD approach is very low. This case study involves high levels of collaboration where all the project stakeholders including the facility management company, which will be responsible for operating the project, are on board from the start. The client organisation led the process of implementing BIM/IPD by employing a BIM management company to educate project stakeholders and bring them to the right maturity level, introduce BIM standards to ensure that information exchange can be done easily and quickly, and to set up the IT infrastructure to ensure full collaboration can be achieved. Case study three is specifically selected where the collaborative

environment is established at the end of the schematic design. In this case study, LoD300 is developed beyond the definition set by AIA to include a complete structural and MEP design to generate accurate quantities for tender documents. The BIM capability of the main contractors is given greater consideration in the selection process. In addition, both the main consultant and contractor have to develop BIM models and are given a good margin of freedom to use their own tools to do that.

Both case studies two and three are also used to validate Phases 1 to 6. Very useful information can also be captured to understand the type of activities that are taken by the various project stakeholders concerning the facility management phase of the building. In addition, the client's representatives are in a good position to feedback on Phase 0, which mainly relates to setting a BIM strategy for the client organisations.

The final process protocol will be drawn based on the three case studies mentioned above and will be recommended to be client organisations as a guide to be adopted for future implementation of BIM/IPD on new construction projects.

## **5.7 Summary**

This chapter has provided a summary of the research methodology employed in executing this research. A qualitative and quantitative approach has been adopted to meet the objectives. Case study has been used as a research strategy, which focuses on understanding the dynamics present within single settings, and allows for the exploration and understanding of complex issues. In-depth data collections have been carried out through semi-structure interviews to validate the findings. The contents of interviews were initially evaluated by relevant industrial partners through comments and recommendations.

This study has adopted the principles of the process protocol, which was developed by the University of Salford. An extensive literature review was also conducted from which the initial process protocol of this study has been proposed. Seven project phases have been proposed for BIM/IPD implementation for client organisations to ensure that a strong client leadership is exercised throughout the design and construction of projects. Chapter 6 will now highlight and discuss the proposed

process protocol and then chapter 7 will report and discuss in detail all three case studies.



# **CHAPTER 6:**

## **The Proposed Process Protocol**

### **6.1 Introduction**

Chapter 3 has explained in detail the importance of managing project information through the implementation of BIM and IPD. Project information can be managed effectively by making project information freely available to all project stakeholders. It is the key to the success of achieving a high level of project integration. This can be achieved with full collaboration between the clients, consultants, contractors, subcontractors and suppliers starting from the early design stages. Clients will get great benefits from the implementation of BIM and IPD by driving a greater degree of collaboration between all the stakeholders. However, the involvement of clients must be guided through a systematic and strategic process to ensure that the collaboration levels can be achieved successfully.

Although the concept and the implementation of BIM and IPD have been around for several years, the industry's stakeholders still having problems and difficulties adapting to this new technology and the concept of project delivery. Several process models and protocols have been introduced in the industry over the past few years, but most of these process models and protocols are not specifically designed for the implementation of BIM and IPD especially from the client's perspective. As mentioned earlier, the execution of BIM and its underpinning business processes need to be carefully represented through the creation of process maps to reflect the relationship between different type of information for the client and the project stakeholders and also the communication tool for the team to refer to.

This chapter represents the proposed process protocol, which has been thoroughly developed through literature reviews. The University of Salford's process protocol has been adopted as the initial concept for this development, the key principles of which

are the Y-axis to represent the project participants as well as the client organisations while X-axis represent the project phases based on the BIM/IPD concept.

## 6.2 The Assumptions Underpinning the Proposed Protocol

The process protocol was developed for client originations who have had repetitive construction works. The client organisations are responsible for the delivery of their own projects as well as being responsible for their timeframe, cost and quality. This includes government organisations and/or large private organisations. It is also assumed that these originations operate under a traditional organisational structure and comprise of a number of departments/units where each department/unit is responsible for certain functions such as the strategic planning, quality control and assurance legal and contracts, projects, quantity surveying (Cost Control) and facility management, as depicted in Figure 6.1. It is also assumed that the design and construction of projects are tendered out and awarded to external consultants and contractors while the client organisations maintain good quality control procedures to ensure that projects are delivered with full client satisfaction.

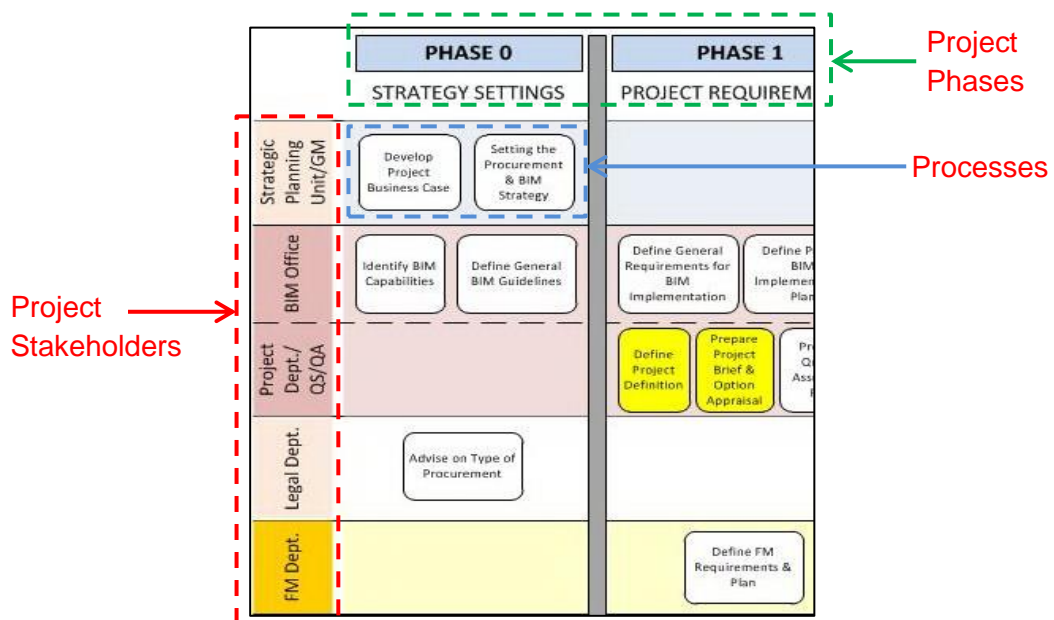


Figure 6.1: Part of the Proposed Process Protocol

### 6.2.1 The BIM Management Office

This research is introducing a new concept of BIM Management Office to effectively implement BIM/IPD across client organisations. The concept is similar to the Project Management Office (PMO), which has been taking a leading role in ensuring that projects are managed effectively within organisations. The BIM Management Office could be an entity within a client organisation with the aim of coordinating and regulating procedures and policies related to the implementation and management of BIM/IPD. The services provided by such an office could range from providing BIM deployment policies and management support functions to monitoring and upgrading skills required for the successful implementation of BIM/IPD.

Within this context, the BIM Management Office could play the following roles, which are similar to the that of the Project Management Office, proposed by the Cranfield School of Management (SOM, 2012) as follow:

#### Basic Services:

- 1 Administrative support for BIM Managers.
- 2 Collating and reporting BIM projects' status to senior management.
- 3 Providing standards, methodologies and a set of BIM development tools.
- 4 Managing BIM documentation (including standards, deployment policy, information exchange, etc.).
- 5 Promoting BIM and BIM management within the organisation.

#### Advanced services:

- 1 Providing a road map for BIM-based applications to maximise the benefits to the organisation.
- 2 Develop a client building elements database for wider organisational use.
- 3 Coordinating BIM implementation plans.
- 4 Monitoring and reviewing project performance.
- 5 Quality monitoring and enforcement of standards.

### BIM Human Resources:

- 1 Developing competencies of personnel, including training and mentoring for BIM managers.
- 2 Providing advice to BIM managers.
- 3 Evaluating BIM managers' performance.
- 4 Recruiting, selecting and/or allocating BIM managers.
- 5 Recording, analysing and disseminating lessons learned.

### **6.2.2 The Process Protocol Components**

The proposed Process Protocol consists of the following major components as shown in Figure 6.2:

- **Project Phases**

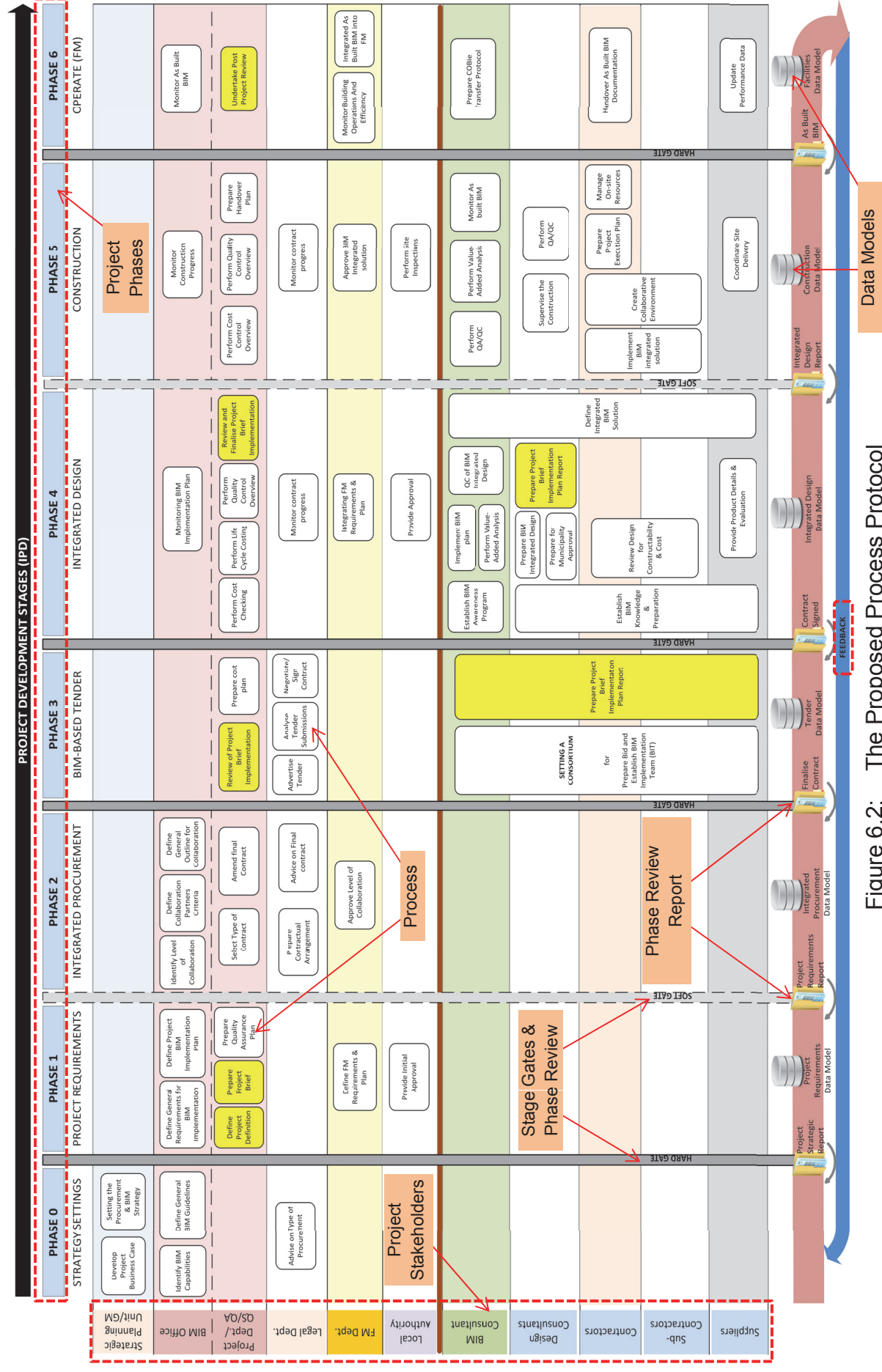
There are 7 phases that have been defined to represent the different stages of the whole lifecycle of a construction project. These start with the strategy setting and capacity assessment phase through to the last phase of facility management.

- **Process**

A set of activities undertaken by project stakeholders within each phase of the process protocol.

- **Project Stakeholders**

The process protocol has been designed to include the project's stakeholders, either a department in a client organisation or an external project partner such as the design consultants, contractors and suppliers. For each phase, the processes to be conducted by project stakeholders are presented so that the concept of the right people having the right information at the right time can be achieved. This process defines the role and responsibility of each stakeholder and the type of decisions required to ensure that each phase is conducted effectively and efficiently.



- **Stage Gate and Phase Review**

Each phase of the process protocol incorporates a set of activities that must be undertaken. Stage gate represents a checkpoint at the end of each phase where prior activities are reviewed before a decision is made to commence the following phase. The process is sequential and the phases cannot be skipped or eliminated.

The process protocol has two types of gates, i.e. “soft” gates and “hard” gates. A “soft” gate allows conditioning moving on to the following phase without the need to complete all the activities of the preceding phase. “Soft” gate represents the flexibility of the process of a particular phase whereby the activities that are not finished in time for the phase review are noted. A “hard” gate on the other hand, cannot be passed through until all the activities of the preceding phase have been completed.

- **Phase Review Report**

After the phase review meeting, a report is produced which includes the key deliverables of work assessed, decisions made and the compilation of all related documents produced during that phase.

- **Data Models**

The creation and use of information and data is recorded and archived for future use, which will aid the continuation improvement process. Data models also can be used, as and when needed, for the integrated design data model during the construction phase.

- **Feedback**

The feedback allows lessons learnt from the completion of the project to be accommodated later to improve and enhance the existing processes in any phase of the project. The feedback also allows the, improvement of data management for every phase of the project.

Details of the process protocol phases will be discussed in the following section, which show the processes before and during each phase including their deliverables

### 6.3 The Process Protocol Phases

The aim of this research is to produce a process protocol, which will help and guide client organisations to implement BIM/IPD successfully. The production of the process protocol was influenced by a number of existing frameworks in the construction and manufacturing industries. The main aim was to produce a model, which could be understood and communicated very easily whilst illustrating the principles and philosophies behind its structure (Kagioglou *et al.*, 1998c).

The proposed process protocol has been developed as a tool which is capable of representing all diverse project stakeholders interested in the process (from setting up an implementation strategy to the development of BIM for the project's facility management). The adopted approach focuses on the concept of IPD and uses BIM as the technological tool that will enable collaboration to take place between the various project stakeholders (both the client organisation and those partners who are hired to undertake the design and construction).

The process protocol encourages client organisations to appreciate processes more easily, affords improvements in communication and co-ordination, provides better control and management of resources as well as the adoption of a 'shared vision' (Goulding and Alshawi, 1999). In addition, the proposed process protocol was developed to improve collaboration between the client organisation and all other project stakeholders who will be responsible for delivering the project.

The main features of the proposed process protocol are as follows:

- Provide an effective setting for the development and implementation of best strategy that can be proposed and provided for client organisations to ensure successful implementation of BIM/IPD.
- Facilitate a collaborative project environment between all project partners from the project's inception to the construction's completion and the facility management of the project.
- Provide a holistic approach within which client organisations can have a better understanding of each phase of the implementation and how the various stages are related to each other.

- Enable client organisations to build up the confidence in the implementation process through the assessment of the outcome of each phase of the process and not to proceed to the next phase until its predecessor is successfully completed.
- Clearly identify the activities that need to be taken by the client organisations and to separate them from those that should be taken by project partners, thus defining the role and responsibility for each party (including the various departments within the client organisations).
- Provide a roadmap for the gradual evolvement of the project's stages and be able to make information accessible to all partners as and when required.
- Map the use of BIM to processes that could facilitate the implementation of BIM for the best interests of the client.
- Increase the speed of delivery through efficiency – both in design and construction through the coordination and execution of the design.
- Reduce the overall construction costs and future life-cycle costs.
- Enable client organisations to produce rich information as well as, accurate and as-built quality BIM models with appropriate links to information on all building elements and systems.

The proposed process protocol follows the concept of the University of Salford's process protocol which consists of X and Y axes, showing the process sequences and process participants, respectively. The horizontal X axis splits into a number of sequential phases separated by "gates". While, the Y axis is splits into a number of rows where each row represents a participant (whether a department in a client organisation or an external project partner), as can be seen in Figure 6.2.

### **6.3.1 Phase 0: Strategy Setting**

This phase aims to establish a strategy for the successful implementation of BIM/IPD for client organisations to ensure that strong client leadership is exercised throughout the design and construction of the project. This is a necessary step that will effectively



produce a change program, which requires high levels of co-ordination and engagement from the various departments/units in the organisation.

#### Before the Phase:

- The Client organisation is expected to have a Strategic Planning Department/Unit, which is responsible for setting long-term plans including the type and nature of future projects along with their anticipated budgets, qualities and timescales. This unit will be responsible for developing:
  - ✓ A business case for the implementation of BIM/IPD which should be clearly identified and understood by the client organisation.
  - ✓ Different procurement approaches to deliver high-quality projects within budget and time.
- The client organisation needs to establish a BIM Management Office to take the roles and responsibilities explained earlier in section 6.2.1 of this report.

#### During the Phase:

- A BIM strategy for the client organisation will be developed along with the types of procurement which are necessary to achieve high levels of collaboration between the project stakeholders.
- The risk and responsibilities for project stakeholders and the Level of BIM Development (Level of Development, LoD) will be defined.
- Capability assessment will be conducted to measure the readiness of both the client organisation and the potential project stakeholders to implementing BIM/IPD.
- BIM guidelines will be documented for both the client and project stakeholders.

#### Deliverables:

- Project Business Case Study

- ✓ Establish the benefits, methods and estimated costs for the implementation of BIM/IPD within the client organisation.
- ✓ Agreed quality standards and time frames
- Project Procurement and BIM Strategy
  - ✓ Provide alternative procurement approaches with a specific focus on achieving high levels of collaboration
  - ✓ Provide the implementation guidelines of the selected procurement approaches
- BIM Strategy and Guidelines
  - ✓ Provide BIM standards and protocols to be used in projects
  - ✓ Provide BIM implementation guidelines for a collaborative project environment between all stakeholders from the project's inception and throughout the facility lifecycle.
- BIM Capabilities Study
  - ✓ Provide the maturity level of the organisation
  - ✓ Provide the level of IT readiness in-terms of software/hardware to successfully implement BIM

#### Goals:

- Establish the requirements for setting up an attractive environment within the client organisation that will satisfy the client's business requirements
- Establish all the procedures and guidelines for the implementing BIM/IPD
- Gain approval to proceed to Phase 1

#### Gate Status:

- 'Hard' gate

### **6.3.2 Phase 1: Project Requirements**

This phase is the start of a set of sequential processes to successfully deliver a specific project for the client organisation based on the assumption that the organisation has a clear understanding of BIM/IPD as a result of Phase 0's outcome. The project requirements encompass a written document, the content and level of details of which vary depending on the relative complexity of the project and the expected procurement route.

Projects should start with a good briefing outline from the Strategic Planning Unit as in its annual report where projects are proposed for the following year. Identifying the true needs of clients in the briefing process is critical to the successful delivery of construction projects. Client satisfaction can be maximised if the client's objectives, as established in the business case for the project, are met. The form, content and extent of the Project Brief are entirely dependent on the particular characteristics of the project and the client.

The BIM Implementation Plan for the project should be outlined at this stage. It should explain the overall vision along with implementation outlines for the project stakeholders to follow. It is highly recommended, at this stage, that the project is allocated to a project manager (champion) to be the "owner" of the project's early processes. Also, the BIM Management Office should produce requirements for the production and utilisation of BIM/IPD such as modelling, visualization, information exchange and analysis, as it should assist in validating the scope and cost of the project. In addition, the quality assurance/control processes need to be identified at this stage to ensure that the project team will adopt "best practices" in the development and file exchange of building information models.

The requirements for utilising BIM for Facility Management (FM) is also essential to enable the client to leverage facility data through its lifecycle to provide safe, healthy, effective and efficient work environments. Having accurate as-built information to reduce the cost and time required for renovations; increasing customer satisfaction; and optimizing the operation and maintenance of the building systems such as reducing the energy usage.

#### Before the Phase:

- Obtain the approval to proceed; normally after the approval of the outcome of Phase 0
- Outcomes from the business case studies have been obtained and agreed
- BIM capabilities and guidelines have been outlined and are ready to be deployed.

#### During the Phase:

- Develop the project brief according to the business case developed in Phase 0.
- The BIM implementation plan will be outlined.
- The quality assurance plan will be prepared.
- Facility Management (FM) requirements for the project will be defined and a plan for FM will be outlined.

#### Deliverables:

- Project Definition and Brief
  - ✓ Provide a comprehensive statement of the client's objectives, requirements and parameters for the project based on close consultation between the client and users in line with the local authority requirements.
- BIM Implementation Plan and Requirements
  - ✓ Outlines the expected levels of information exchange between the project stakeholders when using BIM, particularly for analysis, at different stages of a project.
  - ✓ Outlines collaboration procedures to guide the project stakeholders in the sharing of their deliverables with other partners.
  - ✓ Provide an agreed document on BIM specifications, levels of details and processes for the development and utilisation of BIM.

- ✓ Outlines the roles and responsibilities of the stakeholders to achieve the deliverables.
- Quality Assurance and Control Plan
  - ✓ Establish a Quality Assurance Plan for the development and utilisation of the BIM models to ensure appropriate checks on information and data accuracy.
  - ✓ Provide a checklist to ensure projects are conforming to BIM standards and use best practices in the development and exchange of building information models.
- Facility Management (FM) Requirements and Plan
  - ✓ Provide FM standard requirements to be complied during the life cycle of the project.
  - ✓ Provide the principles of energy efficiency, sustainability and the need for alternative energy sources.

Goals:

- Detail project briefs including all the project requirements
- Identify potential solution(s) for the project collaboration
- A comprehensive BIM implementation plan which specifies project-specific requirements and the quality assurance plan
- Gain authority initial approval

Gate Status:

- 'Soft' gate

### **6.3.3 Phase 2: Integrated Procurement**

This Phase focuses on defining the required level of collaboration between the project stakeholders to meet the project objectives and to set up the legal documents required

to achieve that level of collaboration. The required level of collaboration depends on the scale and complexity of the project, not only the complexity in its design and construction but also in managing its lifecycle (FM). The more complex the project is the higher the required level of collaboration. The latter will also determine the mechanism and stages of the project at which collaboration should take place. The higher the level of collaboration is the earlier it is required during the lifecycle of the project.

A procurement strategy should determine the most appropriate contractual route that the project should take in order to facilitate the collaboration process. The “integrated procurement” phase is used to reflect the multidisciplinary framework that all project stakeholders need work to within to facilitate the defined level of collaboration. An integrated procurement route should ensure that the design, construction, operation and maintenance of the project are considered as a whole and that the delivery team work together as an integrated project team. In addition, any contractual agreements should support risk sharing and incentives, such as financial or non-financial incentives.

Clients, more than other partners, should drive the collaboration process, which should be decided and influenced as early as possible through the procurement route and contractual documents. The client organisation should exercise a strong leadership starting from this phase onward.

#### Before the Phase:

- Project requirements (client brief) should have been produced as an outcome of the previous Phase
- An outline of the required BIM development and analysis for the project should be defined, including type and complexity of the information exchange
- Good understanding of BIM implementation

#### During the Phase:

- Identify the client’s capabilities to manage a project (mainly the department/unit responsible for the delivery of the project)

- Identify the appropriate level of collaboration for the project
- Identify the most appropriate procurement strategy, backed up with contract documents in which roles and responsibilities are clearly defined and risks/awards are clearly explained

Deliverables:

- Level of Collaboration
  - ✓ Provide a clear level of collaboration to carry out the project.
  - ✓ Provide the appropriate communication protocols between all project stakeholders.
  - ✓ Provide a clear and well-defined management process to facilitate the collaboration process.
- Procurement Strategy
  - ✓ Provide a clear route to procure the project in support of the defined collaboration.
  - ✓ Provide a clear and well-defined type of contract documents.
- Contractual Agreement
  - ✓ Outline the roles and responsibilities of all project stakeholders.
  - ✓ Provide clear deliverables for each partner according to the level of collaboration.

Goals:

- Procurement strategy and type of contracts to be selected
- Finalise the contract to be tendered

Gate Status:

- 'Hard' gate

#### **6.3.4 Phase 3: BIM-based Tender**

This phase of the process protocol focuses on preparing the tender documents and awarding the delivery of the project to a consortium of companies based on competitive bidding. The previous phase provided a clear procurement path along with the most appropriate type of contracts that can achieve the project's goals. Depending on the level of the required collaboration, two procurement paths are recommended:

- 1 For large and highly complex projects (such as hospitals, airports, iconic projects, etc.) where a full collaboration level is required, it is highly recommended that the tender should be based on the establishment of professional consortiums where a number of companies bid for the project as a group with clear roles and responsibilities towards achieving the project's objectives as defined by the client brief.

In this context, the contract type could either be a multiple party contract where all partners signed to one contract with the client organisation, or it could be similar to the design and build contract, where one party will be responsible for the delivery of the entire project.

- 2 For level 2 or 3 collaboration, the procurement path could vary based on the required level of collaboration. For example, level 2 collaboration could be based on employing a consultant at the first instance to deliver a design at a schematic detail stage and then employ the main contractor before starting the detailed MEP design. This path will help to establish a collaborative team at the schematic design stage.

In this case, the client organisation should provide a strong leadership to ensure that all parties work towards achieving the project's objectives. Clear roles and responsibilities should be incorporated into the contract for each party.

In either case, client organisations need to have a budget, i.e. a very good cost estimate for the entire project, which the priced tender can be benchmarked against. Whether it is an early design cost estimate, based on option (1) above or a detailed design cost estimate, based on option (2), it is highly recommended that client



organisations have to have their own cost databases for this purpose rather than depending on general published cost information or advice from consultants.

Before the Phase:

- An agreed and approved level of collaboration
- An agreed and approved type of procurement path
- An agreed and approved type of contract in line with the selected procurement path.

During the Phase:

- Client organisation:
  - ✓ Reviewing the project brief implementation specified in Phase Two.
  - ✓ Preparation of the project budget, “client estimated cost” and VE plan.
  - ✓ Preparation of tender and contract documents.
- Project stakeholders:
  - ✓ Setting up a BIM implementation team (BIT).
  - ✓ Prepare project brief implementation report.

Deliverables:

- Reviews of project brief implementation
  - ✓ Outline a clear statement of the standards of quality required; great care is needed to ensure that standards are clear, such phrases as “the highest quality attainable within the control budget” should be avoided.
  - ✓ Outline all project requirements and clearly included in the tender documents.
- Cost and VE plan
  - ✓ Provide overall budget for the project.
  - ✓ Provide the allocation of costs over time.

- ✓ Provide a clear guideline for VE implementation.
- Tender documents
  - ✓ Complete tender documents to be advertised.
- BIM implementation team (BIT)
  - ✓ Outline the roles and responsibilities of all parties collaborated in the BIT.
  - ✓ Provide an agreement framework for all project stakeholders to sign.
- Contract signed
  - ✓ Tender documents to be evaluated.
  - ✓ Negotiation process with the selected tenderer(s).
  - ✓ Complete contract document signed by all parties involved.

Goals:

- Award the project to the most competitive/qualified tenderer
- Establish a collaborative environment through BIT to implement, monitor and evaluate the project's BIM Implementation Plan

Gate Status:

- 'Hard' gate

### **6.3.5 Phase 4: Integrated Design**

This Phase focuses on the delivery of the “integrated design” through a full collaboration between the projects stakeholders. This process is facilitated by BIM. Integrated design is holistic in that it involves all partners, from design to FM, each having input into what goes into the decision-making process that will lead to a fully constructible, functional and cost effective project, i.e. meeting all client requirements. It is holistic in that it takes every team member's point of view into consideration and decisions are made with all the information shared at one time and up front.

The best outcome for this phase can be achieved if project stakeholders are guided by trust, information sharing, collaboration and transparency where team success is equated with project success. As can be seen from the process protocol, there is a condensed level of activities required from each side, i.e. the client organisation and the project delivery team. The former has to ensure that quality procedures are put in place to review and approve the design, i.e. ensuring that the client requirements are met at all times and to perform project analysis to ensure that the best and the most cost effective design solutions are selected, using BIM as the main vehicle.

Yet the project delivery partners focus on delivering the project in line with the client requirements. To do that, the partners should establish a high level of understanding of what they can deliver through collaboration and what functionalities are required in order for BIM to meet the clients' requirements. This process has to be carried out at the early stage of this phase and should be supported by a monitoring process (quality assurance) to ensure that all its elements are fully implemented. It is highly recommended that the QA process is performed by an independent "BIM consultant" in order to provide impartial views on both the data required to achieve the analysis and the outcome of the analysis.

In all cases, the client organisation has to provide a strong leadership to fulfill this requirement.

#### Before the Phase:

- The contract is signed by all project stakeholders involved
- The BIM implementation team (BIT) is setup and ready to collaborate

#### During the Phase:

- Clients:
  - ✓ Monitor BIM implementation plan.
  - ✓ Perform life cycle costing.
  - ✓ Monitor the work progress according to the contract.

- ✓ Perform quality control and a design review of BIM integrated design.
  - ✓ Perform cross checking on estimated project cost and design quality using BIM models.
  - ✓ Integrating FM requirements and plans at the early stage of the design.
  - ✓ Review and finalise project brief implementation according to the project requirements.
- Project stakeholders:
    - ✓ Establish BIM awareness program and build up BIM knowledge among BIT.
    - ✓ Implement BIM implementation plan including IT infrastructure, software and training.
    - ✓ Prepare integrated BIM from concept (LoD100) to detail (LoD300).
    - ✓ Provide Quality Control (QC) procedures to streamline the content and development of BIM.
    - ✓ Establish a collaborative environment to enable information sharing among all partners.
    - ✓ Collect product information from suppliers to be used during design evaluation.
    - ✓ Prepare project brief implementation report.
    - ✓ Preparation of all related documentations for the authority approval.

Deliverables:

- A finalised project brief implementation report
  - ✓ Integrated design will be reviewed according to the project requirements.
- Cross checking report

- ✓ Life cycle costing will be aligned with the pre-defined cost plan.
- ✓ Quality control of the integrated design will be aligned with the pre-defined VE plan.
- An established BIM awareness program to be conducted throughout the project
  - ✓ Develop a series of programs or workshops for disseminating BIM knowledge to all partners involved.
  - ✓ Assists BIT on the execution of the BIM implementation plan.
- A complete and comprehensive integrated BIM to detail level (LoD300)
- Authority approval

Goals:

- A collaborative environment where all parties join together to achieve the objectives of the project
- An integrated BIM design model, fully coordinated and clash free, and is capable of fulfilling all analysis required by the client.

Gate Status:

- 'Hard' gate

### **6.3.6 Phase 5: Construction**

The construction phase of the process protocol focuses on the delivery of the project to the highest satisfaction of the client. At this phase the contractor should have an excellent understanding of the project to be delivered and should have played a significant role, as a part of the collaborative team, in making the design constructible with clear and complete specifications. In addition, specialised subcontractors should also be on board along with the suppliers who should have already contributed to the manufacturing and performance of the various building elements.

The contractors should continue to work with the project collaborative team, during this phase, to ensure that the BIM implementation plan is fully implemented. The implementation plan should clearly define all the building elements, products and systems that need to be incorporated into the BIM model to be used either for the analysis required during the construction stage or for the facility management of the building. This is a difficult task as the amount of information required to be collected from different partners might be very large. Hence, the continuous collaboration between the project stakeholders will be vital to balance between the required information and the value that it could add to the project. In addition, BIM should be updated continuously throughout the construction phase to produce the As-Built BIM, i.e. LoD500, which should also include all RFIs, change orders, and as-built/as-constructed changes that occur during construction.

The client organisation, on the other hand, should continue to provide a strong leadership during this phase to ensure that the project meets all the client requirements. This is mainly materialised by strict quality control procedures to be complied by all the project stakeholders along with a continuous implementation of cost control procedures to ensure that the project team meet their cost and time targets. The FM Department should also take part in this phase to ensure that project stakeholders meet all the FM specifications and that all information required for managing the building after handover is taken care of.

#### Before the Phase:

- The BIM implementation plan is fully executed at the design stage
- All parties involved are equipped with the necessary BIM knowledge, training and IT infrastructure required to execute BIM development
- Integrated BIM for LoD100 to LoD300 are developed
- Full add value analysis have been carried out on the integrated design
- Integrated BIM is reviewed and verified
- Life cycle costing is performed

- Local authority approval for the design is obtained

During the Phase:

- Client:
  - ✓ Monitor the construction progress according to the contract.
  - ✓ Perform cost and quality control overview.
  - ✓ Prepare for handover plan with the agreed requirements and outcomes.
  - ✓ Perform site inspections to ensure compliance with the project requirements, regulations etc.
  - ✓ Approve BIM integrated solution for FM to ensure the continuation of BIM usage into FM.
- Project Stakeholders:
  - ✓ Perform cost and energy analysis on the integrated BIM models including the actual materials used.
  - ✓ Perform schedule simulation on the integrated BIM models to visually plan and communicate activities in the context of space and time.
  - ✓ Extend the integrated BIM models from LoD300 to LoD400.
  - ✓ Perform interference check and cross-discipline BIM data for the completeness of the BIM models.
  - ✓ Monitor changes in the BIM model and collaborate with all the parties if any changes or updates are made.
  - ✓ Maintain the collaborative environment, which uphold the capabilities to share information among all parties.
  - ✓ Develop and approve shop drawings to be used in the fabrications and update the details in the BIM models for later use.

#### Deliverables:

- Project handover plan
  - ✓ Provide project handover checklist - reviewed, amended and updated.
  - ✓ Outline details of FM in the handover process.
  - ✓ Outline the operational and maintenance contractual arrangement.
  - ✓ Outline client engagement and training plan.
  - ✓ Outline client occupation/migration plan.
- As-Built BIM Models
  - ✓ Include the as-built documents that contain mark-ups, annotations, and comments about changes that have been made to the contract documents during the construction phase.
  - ✓ Include the as-built models that have been updated throughout the construction process. These changes and updates have been communicated from the contractor to the design team through the comments, annotations and mark-ups from the As-Built Documents.

#### Goals:

- Deliver the project as planned within time and cost
- Develop as-built BIM models from the project execution

#### Gate Status:

- 'Hard' gate

### **6.3.7 Phase 6: Operate (FM)**

This phase focuses on the FM stage of the project, where build information is critical to help client organisations (or their FM contractor) to formulate a long-term



maintenance strategy. Through, its strong leadership and the quality control procedures that should have been exercised during the previous phases of the process protocol, client organisations should be able to ensure that all information required for the production of the as build BIM model have been captured and populated into the model. The format and depth of such information can follow the information exchange standards COBie (Construction Operations Building Information Exchange), which facilitates the transfer of digital information from the design and construction process to the facilities management databases. Thus, implementing BIM and COBie would streamline project activities with the most immediate tangible benefit being improved tracking of warranty information to avoid potentially significant costs associated with unnecessary equipment repair or replacement during the warranty period.

A critical stage after the completion of construction is the handover of the project to the client organisation. This process should be easier to manage mainly because of a) the client involvement in and knowledge of all phases of the process protocol, and b) the availability of the quality assurance documents that should have been produced during the design and construction and approved by all partners. Suppliers and specialised subcontractors, such as MEP subcontractors, in particular, have to keep updating the performance data of equipment and systems over the guarantee period.

#### Before the Phase:

- Overview of the actual costs and quality control documents are produced
- Outline handover plan is developed
- As-Build BIM models are developed and approved

#### During the Phase:

- Client:
  - ✓ Conduct post project review to measure how the project meets its requirements.
  - ✓ Monitor handover building operation.

- Project Stakeholders:
  - ✓ Prepare data transfer protocol to facilitate the transfer of digital information from the design and construction process to the facilities management databases.
  - ✓ Suppliers update performance data in order to keep the supplied equipment performance up-to-date.

Deliverables:

- Post Project Review Report
  - ✓ Review the completed project in terms of meeting project briefs and objectives.
  - ✓ Provide a basis from which lessons learnt may be applied to future projects.
  - ✓ Continuous monitoring and feedback of performance to improve future projects.

Goals:

- Integrating BIM with Facility Management
- Measurement of the efficiency of the building operation and maintenance during the handover process

Gate Status:

- No formal gate status. The overall feedback from all phases will contribute and improve the project delivery strategy, requirements, type of procurements and the execution of the project using the proposed BIM implementation plan.

## 6.4 Summary

This chapter represents the initial process protocol, which was proposed and thoroughly developed through an extensive literature review. The University of Salford's process protocol was adopted as the initial concept for this development. Several major components, backed by the original key principles of the process protocol highlighted earlier in Chapter 4 were proposed, i.e. project phases, processes, project stakeholders, stage gate and phase review, data models and the feedback.

The proposed process protocol follows the concept of initial process protocol which consists of X and Y axes, showing the process sequence and process participants, respectively. The horizontal X axis is split into a number of sequential phases separated by "gates". While, the Y axis is split into a number of rows where each row represents a participant (whether a department in a client organisation or an external project partner). All proposed seven phases are presented including all actions before the phase, during the phase, deliverables, goals and gate statuses at the end of each phase. The proposed process protocol needs to be validated through case studies and will be discussed further in the following chapter.

# CHAPTER 7

## Case Studies

### 7.1 Introduction

Chapter 5 discussed the research methodology principles that were followed in this research study. It highlighted the quantitative and qualitative approach including the importance of case studies and how they can be conducted. Questionnaire were developed and used during semi-structured interviews with the project stakeholders. Case Study One was selected to explore a phenomenon where an initial process protocol (roadmap) for BIM/IPD implementation needed to be established at client organisations.

Three typical high-rise building projects (residential and commercial) have been selected for the case studies. Case Study One provides a “control case” to investigate the possible effect of the new delivery method, i.e. IPD, on projects in the UAE. The findings show that the process protocol that was initially developed has been updated to suite local conditions. In addition, the analysis of the results showed that there are nine important criteria that underpin the main process protocol. These include: client leadership, project brief, capacity/maturity, project phase decision, facility management, contracts, collaboration, BIM management and BIM-based application.

Two further case studies have been conducted to validate the process protocol focusing on the nine criteria. Several semi-structured face-to-face interviews have been conducted with staff from the client committee, including consultants and contractors for both case studies. The interview results have been recorded and the important views have been highlighted. This chapter explains the three case studies and how they carried out the work. The findings are discussed in Chapter 8.

## 7.2 Presentation of the Case study

The contribution of the case studies to the validation of the process protocol is shown in Figure 7.1. Following the University of Salford's process protocol, along with a comprehensive literature review, an initial concept was developed. The initial process protocol was then validated with three selected case studies, with the aim to: (1) initially validate against the UAE local conditions and demonstrate the justification for using BIM/IPD; and to (2) verify and strengthen all the proposed components of process protocol at the different levels of collaboration.

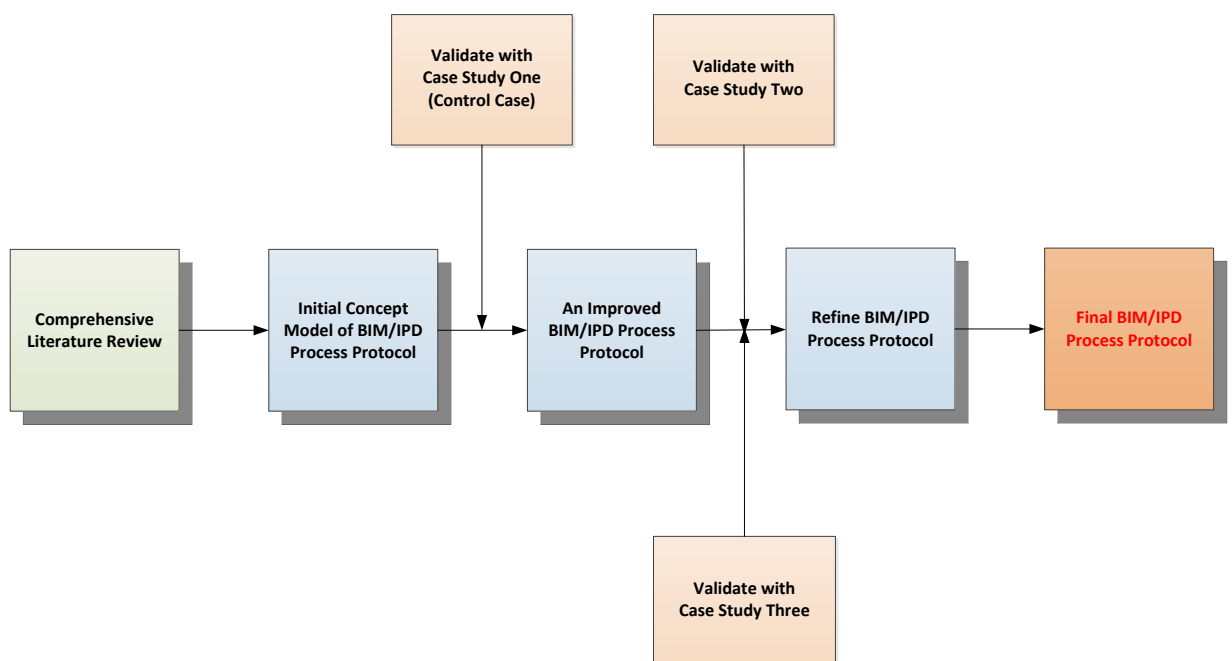


Figure 7.1: Case Studies Structure

These three case studies are presented in a similar way within this chapter although they are different in their contribution to the validation of the research. In each case, the construction project is firstly described, such as the nature and type of the project, procurement approach, size, location, etc. This will then be followed by a full description of the adopted approach to successfully complete the case. The interviewees' background for each case is then explained.

As Case Study One is different from Case Study Two and Three, its findings have been tabulated in order to make it easier to list the site problems and to relate them to their causes. While the findings of both Case Studies Two and Three were explained

under the nine criteria, mentioned above, where comments made by the interviewees are listed. Each area of the criteria is presented with general comments describing their related features to the study.

Table 7.1: The Outline of the Presentation Structure of Each Case

❖ Description of the construction project
❖ Approach to the cases
❖ Interviewees background
❖ Case study findings

## 7.3 Case Study One

### 7.3.1 Project Description

Case Study One is a large project with the overall scope of constructing a 330 meter mixed-use tower (residential and commercial) with an estimated monthly income of \$4 million. The project includes the construction of five basements (reaching a depth of 25 meters underground), one ground level and 72 floors rising from the base, making the project's overall value around 1.5 billion UAED (\$495 million). The total built-up area of the project is 230,000 squared meters with a projected additional underground parking structure taking the total to 40,000 squared meters. The project has a central reinforced concrete core containing lifts, service shafts, circulation and staircases. It is supported on a four-meter thick raft slab plus a 54 meter steel structure, which means that the penthouse (Sky Garden) is at Level 67. This level also includes a swimming pool.

A number of international partners are involved in delivering its design and construction. The delivery of the project is based on the typical traditional project delivery practices in the local UAE construction industry. It has suffered from long delays and high cost overrun. This project is selected due to the availability and ease of access to the required information.

The project adopted a traditional procurement approach (design, bid and construct) where a direct contract agreement was signed between the client and each of the following parties:

- 1 An international project management company.
- 2 An International consultant – as the lead consultant.
- 3 A joint venture between two main contracting companies (one local and one international).

The tender process was carried out on the basis of a traditional lump sum contract with the inclusion of four specified domestic trade packages (i.e. façade work, vertical transportation, canopy and top of the tower steelwork). The total estimated duration was 40 months from the start of the construction process, i.e. from March 2007. The program of work predicted the completion (handover) date to be July 2010. The later was adjusted with an anticipated handover date of January 2013.

The project management company undertook the feasibility study for the project, produced the client brief and contract templates, whilst the lead consultant created the sub-consultant agreements/contracts for the relevant sub-consultants of the various technical disciplines. There is almost zero level of collaboration between all stakeholders as each stakeholder has separate individual contracts with the owner. All stakeholders had their own scope setup. Separation of contracts amongst the project management and the consultants created difficulties for collaboration due to separated agendas and missions.

### **7.3.2 Approach to Case Study One**

The first case study was used as a “control case” to validate the suitability of the proposed process protocol for the UAE’s local experiences and conditions and to investigate the real reasons behind the delays, their causes and how they could have been adequately addressed if a new delivery method had been adopted by considering the concepts of BIM, IPD, client leadership and collaborative environment. Case Study One has investigated the main problems that were encountered during the construction of the project. Qualitative research was conducted including semi-

structured interviews with the main parties involved: members of the client committee, the client representatives on-site, the project management company and the contractor to discover the real reasons behind the delay. Special focus was also placed on client leadership and the role that the client can play in eliminating/minimizing these problems. Information about the delays were collected and then analysed and categorised into a number of groups based on their significance in terms of time and cost.

The case study concentrates on the impact of the following factors:

- Virtual modeling through BIM
- Project delivery using IPD (BIM and IPD)
- Collaborative environment only
- The client leadership role as a catalyst and driver

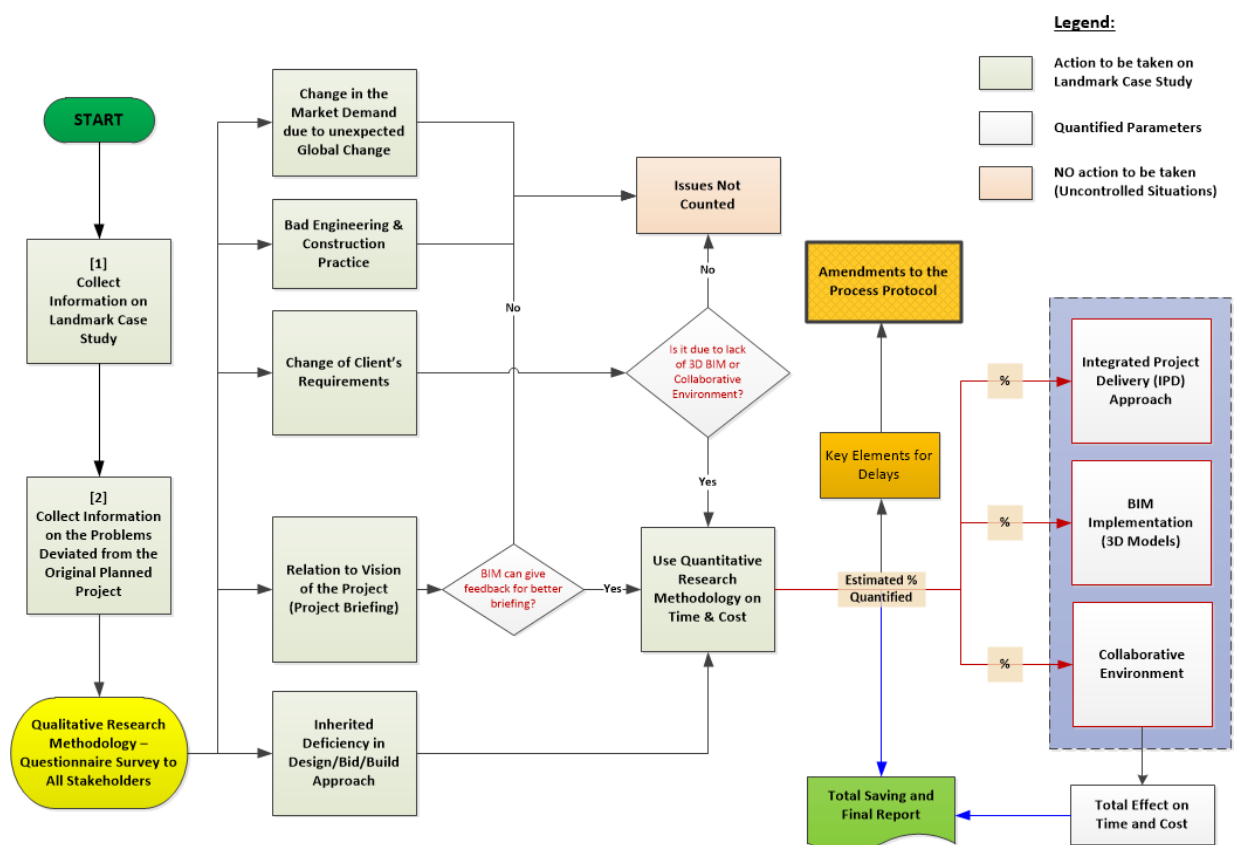


Figure 7.2: Approach to Case Study One



Figure 7.2 shows the methodology used to conduct this case study as described below:

- 1 General information about the project was collected mainly from the client representative.
- 2 A list of open questions were prepared to elicit the information from the main project partners, i.e. the main contractor, project management company, main consultant and client representative.
- 3 Semi-structured interviewed were carried out with each stakeholder separately and all information was documented.
- 4 Detailed analysis and categorization of the findings was then carried out.
- 5 Each identified problem was discussed with local experts (mainly from the client office) to find out how such problems can be avoided in future projects along with the challenges facing the client in avoiding these problems in the future.
- 6 The expected cost and time caused by each of the identified problems was established.
- 7 Key elements (causes) were derived from each identified problem, which was then traced back to the process protocol phases and processes.
- 8 The information obtained from point (5 and 6) was used to measure the impact of the identified key elements on time and cost to help the study to quantify the losses of the project (detailed findings are presented in Chapter 8).

### **7.3.3 Interviewees Background**

Semi-structured interviews were held with the project management company (the project manager), the contractor (the contractor's project manager), the consultant (the designer and quality control) and the client representative (the resident engineer).

#### **a) The Project Manager**

The project manager is the leading representative of the project management company, who was responsible for managing the entire project. The interview was conducted to gather his views on the problems and challenges that were faced

during the construction stage and how he could relate them to their possible causes.

b) Contractor's Project Manager

The contractor's project manager represented the joint venture responsible for contracting organisations and reporting to both the client and the consultant. The interview was aimed mainly to understand the difficulties the contractors went through, problems encountered, possible causes and how they could have been avoided.

c) The Resident Engineer

This person is the client representative on site with very strong industrial and academic experience. The interview focused on the problems on site from their own perspective, as a client representative, and what the main causes of these problems were.

The interviews were deliberately kept as open as possible to elicit as many issues/problems as possible from the interviewees. However, to avoid losing focus, the interviews were conducted under four main criteria:

1 *Detailed Information of the Project:*

This included general descriptions of the project, partners involved, procurement methods, adopted management practices, project management structures, approval processes, estimated budget, estimated costs and estimated completion time.

2 *Current Status of the Project:*

This included issues such as changes in design, value of the work thus far, delays incurred, cost overrun etc.

3 *Views on Design and Construction Methods:*

This included the main problems faced during the design and construction phase.

#### 4 *The Main Issues that led to the Highlighted Problems:*

This included procurement methods, the collaboration between partners, approval processes, supply chain management, etc.

### **7.3.3 Outcomes of Case Study One**

The project faced many challenges during the course of construction. In particular the introduction of a Plaza Enclosure for the building's main entrance with an area of 4,000 squared meters. This happened when the client realized, at the construction stage, that both the escalators and the elevators for the disabled (which are specifically designed to lead people directly to the second floor, i.e. avoiding the ground floor entrance) are exposed to weather conditions. The client identified that the operation of the escalators and elevators will be severely affected by maintenance time, plus the high cost of maintenance. This triggered off an action to introduce the Plaza Enclosure with an estimated cost of 100 million UAED. In early 2011, a supplementary agreement was signed with the lead consultant and contractors to design and construct the Plaza. This happened at a time when the project had already veered offtrack due to other delays, which had added more complication to the project.

The other main challenge was the client's decision to change the use of levels 8 to 35 from residential to office space in an attempt to improve the "rentability" of the project in light of the economic down turn in this area. The estimated saving in construction cost due to this change was 70 million UAED. This happened during the construction stage too where the project partners faced great difficulties in coordinating all the changes while maintain the integrity of the design and reducing the cost.

A careful analysis was carried out on the collected information from the project management company, contractors and client representative. Information was cross-referenced to ensure that "biasness" was eliminated and that findings reflected a good level of accuracy, particularly in terms of their "real causes". The latter was then discussed with the client office represented by a highly qualified structural engineer with more than 30 years of experience in designing and managing large and complex projects in the UAE.

During the interviews the main contractors highlighted some issues, which they had to deal with that had not been considered during the design stage by the consultant. These included:

- 1 Helipad;
- 2 Parking requirements;
- 3 Canopy protection from falling objects;
- 4 Balconies' purpose, locations and cladding materials and accessories;
- 5 Curtain walls' specifications do not serve project local condition (Gulf region);
- 6 Compliance with local codes; and
- 7 Discrepancies between specifications and drawings (many were cut and pasted without a proper review).

Also, the contractor summarized their views on the causes of the delays as follows:

- 1 More than 12 months delays caused by the consultants approval and decisions processes;
- 2 Ten months caused by The client representative's (CR) decisions;
- 3 Six months caused by the CR/consultants inflating issues beyond reasons;
- 4 Four months caused by the fact that some designs and layouts were not as per local authority requirements;
- 5 Transfer level's structural design in complete;
- 6 Eighteen months of delays due to very high specification to some of the finishing;
- 7 Six months due to exaggerated inspection reporting;
- 8 Unreasonable cost control and payment procedures; and
- 9 Unreasonable rejection of legitimate extension of time.

Both the client representative and the project manager preferred to highlight the problems that the project faced first and then to discuss their possible causes. Their approach was different to the contractor's and therefore their input was analysed and cross-referenced to the contractor's. The findings of case study one are listed in Table 7.2.

Table 7.2: List of Case Study One Findings

Event Description	Context & Reasons (Results of the qualitative research study)	Classification and Challenges (How the problem can be avoided and what are the challenges facing its implementation)	Time Impact Months	Cost Impact UAED
MEP Design Related Problems				
Insufficient MEP Design	<p><b>Context</b> At post contract stage, due to economic climate changes, the Client requested to transfer residential floors (L8-L35) from residential to commercial.</p> <p>This has resulted in a change in demand on the cooling load which has led to new design parameters for the cooling system.</p> <p>After the review of the new detailed design parameters, it was found that the capacity of the initial design was insufficient and needs to be increased.</p> <p>This has resulted in a design change of the cooling system which had to be approved by the Client.</p> <p>The MEP design had an Impact on other related construction activities such as interior finishing, testing and commissioning.</p> <p><b>Reasons</b> Lack of design coordination, particularly after the change of use.</p> <p>The lack of good planning to ensure that the impact of change of use is carefully measured on all aspects of design (architecture, structure and MEP)</p>	<p><b>What should have happened</b> A Client led task group (consisting of all project partners) should have been established with clear objectives to meet the Client's new requirements.</p> <p>A clear work plan should have been produced and agreed by all partners. This could have an impact on the initial contractual agreements, by which contracts amendments should have been produced.</p> <p>Quality assurance procedures should have put in place to ensure that tasks are met with the highest possible quality.</p> <p>The QA procedures should have included a clear review process not only to ensure that the design is fit for purpose but also that it meets its cost target.</p> <p><b>Challenges</b> The initial lack of coordination between the concerned partners meant that each partner works in isolation from the others. Scope of work defined by the initial contracts has limited the partners to work towards a common objective, i.e. maximizing Client satisfaction. In fact,</p>	Overlaps	5.0M (This is the agreed amount between the Consultants and the Contractor for the reworks)

	and that appropriate tasks are planned to successfully meet the challenge.	each partner works hard to protect his interest and to minimize the risk on his company.		
Placement of the major electromechanical plant on the roof of the building	<p><b>Context</b></p> <p>The initial MEP design allocated the chillers and cooling towers on top of the building.</p> <p>The consequence of this design is that the system cannot be installed until the building structure is completed.</p> <p>The configuration of the system also made it impossible for the risers to be utilized temporarily from mobile chillers located at the ground level</p> <p>The building has 72 floors, which meant that MEP testing cannot be made until the cooling system is installed, including wild air circulation.</p> <p>This has had a significant delay impact (12 months), mainly on the installation of interior finishing.</p> <p><b>Reasons</b></p> <p>The absence of a strong Client leadership along with a comprehensive Client brief led to minimal control on the initial design process</p> <p>There was no constructability evaluation of the MEP design. The impact of the installation of the chillers and the cooling towers on other construction activities were not checked.</p> <p>There was a complete absence of the role of the Contractor even at the end of the detailed design.</p>	<p><b>What should have happened</b></p> <p>The Client should have played a stronger role in leading the revision of the final design. Clear evaluation criteria should have been outlined including constructability, performance and maintainability of the system.</p> <p>Detailed simulation of the construction process should have been carried out prior to commencement of construction. This would have clearly highlighted this issue if it was not discovered in the design review.</p> <p>The adoption of BIM at the early stage should have also facilitated both the simulation of construction and the visualization of the system.</p> <p>The main contractor and the MEP specialized subcontractor should have participated in evaluating the final design to ensure that constructability of the project is fully taking care of.</p> <p><b>Challenges</b></p> <p>The traditional procurement system makes project partners work in isolation of each other. This makes collaboration extremely difficult, as each partner will be looking after his own interest.</p> <p>Local culture and practices make it difficult to adopt new approaches that deviate from the norm.</p> <p>The lack of awareness and adoption of the latest technology such as BIM to improve construction on site.</p>	12months	Loss of income equal to 177.0M

Delay commencement of wild air and testing and commissioning	<p><b>Context</b> As a consequence of the above event, there was a significant delay on commencement of wild air too.</p> <p>Work could not start before the installation of the cooling system on top of the building.</p> <p>This activity has also been affected by the delay in closing the building envelope.</p> <p><b>Reason</b> Constructability of the design solution was not considered</p> <p>There was a complete absence of the role of contractors at the detailed design.</p> <p>Ineffective planning resulted in weak coordination between the various construction activities.</p>	<p><b>What should have happened</b> A detailed simulation of the construction process should have been carried out prior to commencement of construction. This would have clearly highlighted this issue.</p> <p>The adoption of BIM at the early stage should have also facilitated the simulation of construction and hence discover problems in planning at the early stages.</p> <p>The main contractor and the MEP specialized subcontractor should have participated in evaluating the final design to ensure that constructability of the project is fully taking care of.</p> <p><b>Challenges</b> The lack of awareness and adoption of the latest technology</p> <p>Local culture and practices prevent closer collaboration between the project's partners. This always led to poor and uncoordinated planning.</p>	7 months	Loss of income equal to 103.6M
Introduction of the Plaza				
Introduction of Plaza enclosure	<p><b>Context</b> The original design of the project included two escalators at the entrance of the building to divert part of the pedestrian traffic to different levels of the building.</p> <p>The two escalators were external and exposed to the adverse weather conditions of the region.</p>	<p><b>What should have happened</b> The problem should have been avoided right from the early stages of design if the design was fully evaluated through 3D visualization and life cycle costing.</p> <p>There should have been a Client requirement which enforces formal participation of the Client in the design process.</p>	Overlaps	100.0M (signing of a supplement agreement)

	<p>Half way through the construction, the Client discovered the fact that two escalators have no cover and that they need weekly maintenance which can severely affect their operation.</p> <p>Maintenance plans and costs were not considered effectively during the design stage.</p> <p>The Client has to introduce a new enclosure to cover the entire entrance area. This has resulted in the addition of retail space and subsequently the demand for about 200 extra car parking. The adjacent land to the project was purchased to satisfy the parking demand</p> <p>The new enclosure had other impact on MEP design particularly the cooling system.</p> <p><b>Reason</b></p> <p>The absence of a strong Client leadership along with a comprehensive Client brief led to minimal control on the initial design.</p> <p>The Client was unaware of the detail design. The exposure of the two escalators was only discovered during the construction stage.</p> <p>The life cycle cost was not taken into consideration during the design stage</p> <p>Unfamiliarity of the International Consultants with the local weather conditions.</p> <p>Contractors and specialized subcontractors were not involved in the design stage to allow for the local experience to be embedded into the design.</p>	<p>As the design was produced by an international company, local contractors and subcontractors should have been involved in the design to ensure the constructability and maintainability of the project.</p> <p>Technology such as BIM should have been implemented to address this problem early in the design stage.</p> <p>A clear work plan for this addition should have been produced with an overall agreement on its tasks from all the concerned partners. Clear line of authority should have been established specifically for this activity to ensure the production of quick and effective solutions.</p> <p><b>Challenges</b></p> <p>The local market lacks the awareness of the latest technology such as BIM.</p> <p>Life cycle costing is not a requirement and hence consultants are not obliged to do it.</p> <p>Project management companies (whether local or international) seem not to adhere to the latest development in procurement and project management practices and thus leaving the line of authority unclear.</p> <p>Clients seem to have a relaxed role in controlling and monitoring design changes.</p>		
--	---	---	--	--



<p>Delay of the finalization of the canopy frit pattern and design</p>	<p><b>Context</b>  The introduction of the Plaza enclosure required the production of a Canopy design to cover the wide enclosure space.</p> <p>This necessitated the selection of a new steel design which required two design revisions.</p> <p>In addition, the revised wind tunnel report indicated that the North Canopy needed to be modified in order to cope with the uplift in loads.</p> <p>Although a deadline was agreed to produce and agree on the final design, the request for change was submitted six months late.</p> <p><b>Reasons</b>  The lack of clear line of authority made the decision making process difficult and lengthy</p> <p>The Contractor did not provide design calculation on time</p> <p>New materials (cables and steel sections) were not presented for approval on time</p>	<p><b>What should have happened</b>  The Client should have played a stronger role in managing and controlling the design process, including undertaking a full evaluation of the impact on construction.</p> <p>A Client led task force, comprising all project partners, should have been created with clear deadlines to ensure producing a fully coordinated design.</p> <p>The adoption of BIM should have facilitated the production of new materials quickly and effectively.</p> <p>Detailed simulation of the construction process should have been carried out to ensure that problems are “eliminated” prior to construction.</p> <p><b>Challenges</b>  Construction was underway when this decision was taken, making changes expensive to undertake.</p> <p>The existence of non-collaborative environment made it difficult to create a Client-led task force to manage the design of the Canopy.</p> <p>The contractual agreements (traditional procurement) prevented individual partner from taking the risk to be proactive in finding practical solutions, i.e. each partner was looking after his own interest and NOT the Client's.</p> <p>The lack of awareness and adoption of the latest technology</p>	<p>Overlaps</p>	<p>2.3M  (Agreed variation order for redesign and the actual work)</p>
--	--	---	-----------------	--

Architectural and Structural Design Related Problems				
Value engineering and value engineering reversal	<p><b>Context</b></p> <p>At post contract stage, the Contractor was asked to carry out VE as a cost reduction exercise. The study resulted in 75m UAED saving, mainly in design alterations.</p> <p>The Contractor was given the go ahead to proceed with the design alterations, by the project manager, before getting the final approval from the Client. New design drawings were produced.</p> <p>The VE outcomes had to be reversed by the Client causing 50M UAED and another 25M UAED in claims.</p> <p><b>Reasons</b></p> <p>No clear line of authority. Roles and responsibilities, communication strategy, contractual agreements, etc. were not clearly defined. Each party try to take an initiative to get the work done according to its understanding and motives.</p> <p>The absence of a clear and approved project's objectives, work plan and Client requirements and leadership led to a fragmented process which made it difficult to control and/or predict.</p>	<p><b>What should have happened?</b></p> <p>Client leadership is critically required to ensure requirements, directions and project's objectives are clearly defined to all partners, i.e. all have to work toward achieving the Client's benefits.</p> <p>Each party should have had a clear role and responsibility supported by a "watertight" contractual agreement. Roles and responsibility matrix should have been created and agreed to show the relationship between the various partners.</p> <p>Line of authority (decision making process) and effective approval process should have been made absolutely clear to all partners.</p> <p>VE exercise should have been completed and approved prior to construction. Changes should have been covered in the tender to ensure effective costing.</p> <p>The above point can only be performed effectively if contractors and subcontractors participate in the VE exercise during the design stages.</p> <p><b>Challenges</b></p> <p>The traditional procurement system makes project partners work in isolation. This makes collaboration extremely difficult, as each partner will be looking after his own interest.</p> <p>Local culture and practices make it extremely difficult to introduce change.</p>	2 months	<p>75M (This is related to the saving made) + Loss of income equal to 29.6M</p>

<p>Detailed design - Design discrepancy</p>	<p><b>Context</b>  After awarding the contract to the main Contractor, the latter will have the responsibility to complete the project in line with the initial design intent.</p> <p>After the approval of the detailed design, the Consultant's role was shrunk to a site supervision role with a loose contractual agreement. (The site supervision team was different from the initial design team). This made the process of conveying the design intent to the Contractor extremely difficult.</p> <p>Incomplete and inconsistent design drawings along with incomplete specifications open the door for the main Contractor's to interpret the design drawings which led to large number of variations.</p> <p><b>Reasons</b>  The lack of design coordination, at the design stage, resulted in inconsistent design drawings.</p> <p>The lack of an agreement to coordinate the production of detailed design through an automated system.</p> <p>No clear standards for generating detailed specifications, such as the UK National Building Specification (NB), which led to a design with incomplete specifications.</p>	<p><b>What should have happened</b>  The design process should have been coordinated using an agreed standard such as BS1192. This should have also covered in the Consultant's contract.</p> <p>Client leadership should have been exercised during the design stage to ensure the implementation of the coordinated system.</p> <p>Specifications standard should have been agreed by the Client and adopted by the Consultants.</p> <p>The consultants or the Client should have proposed and adopted an automated system to manage the design process.</p> <p>Involving the main Contractor prior to tendering would have highlighted the majority of the design discrepancies by reviewing the design with the Consultant.</p> <p><b>Challenges</b>  Local practices give full design responsibility to consultants with little Client involvement and no clear authority to monitor and review the design development.</p> <p>Giving the design to international consultants with little, if any, awareness of the local contractors' experience and markets.</p> <p>Lack of local specifications standards.</p>	<p>Overlaps</p>	<p>8 M  (This is a combined value claimed by the Contractor)</p>
---	---	--	-----------------	--

Improper quality control for the structural reinforcement work	<p><b>Context</b> The structural design caused some building elements to be highly congested with steel reinforcement. This made the normal concrete mix unsuitable, i.e. gravels can't pass through and/or can't be compacted effectively. This problem was discovered on site as construction progressed, and solutions were produced on site.</p> <p>Both the Contractor and the Client representative addressed this problem either by redesigning building elements with different system such composite steel and concrete sections OR order special concrete mix such as micro-concrete/self-compacted concrete</p> <p><b>Reasons</b> Design codes were not strictly adhered too</p> <p>Constructability of the structural design solution was not considered.</p> <p>There was a complete absence of the role of the local contractor at the detailed design.</p>	<p><b>What should have happened</b> A detailed modelling of the structural design in BIM should have discovered this problem at the early design stages.</p> <p>At the design review, the 3D visualization of the detailed structural elements should have clearly highlighted this problem.</p> <p>The involvement of the local contractors at the design stage and their participation in the review of the structural design should have raised this issue.</p> <p>A detailed simulation of the construction process should have highlighted this issue if it is not discovered at the design review.</p> <p><b>Challenges</b> The lack of awareness and adoption of the latest technology such as BIM</p> <p>Local culture and practices prevent closer collaboration between the project's partners. This always led to poor and uncoordinated planning</p>	3months	<p>10M (This is a combined value claimed by the Contractor) + Loss of income equal to 44.4M</p>
Inadequate planning for the transfer structure	<p><b>Context</b> At post contract stage, due to the economic climate impact, it was decided to change levels 8 to 34 of the building from two bedrooms apartments to offices.</p> <p>This has a significant impact on the architecture, structure and MEP design;</p>	<p><b>What should have happened</b> The Client should have played a stronger role in managing and controlling the design amendment process, including undertaking a full evaluation of impact on construction.</p> <p>A Client led task force, comprising all project partners, should, have been created with clear deadlines to ensure producing a fully coordinated</p>	3 months	<p>10M (This is a combined value claimed by the Contractor) + Loss of</p>

	<ul style="list-style-type: none"> <li>➤ Floor to ceiling height has to go up from 4.25m to 4.5m</li> <li>➤ Post tensioned slabs have to be introduced to increase floor to ceiling height.</li> <li>➤ Change of air conditioning system from FCU to VAV</li> <li>➤ Extra parking spaces were required (as per Local Authority requirements) which resulted in additional underground parking and using of an adjacent plot of land</li> </ul> <p>An external consultant was engaged to undertake the required structure changes.</p> <p><b>Reasons</b> This decision was mainly taken to improve return on investment due to economic conditions in the region.</p> <p>The lack of coordination between the Consultant, Contractors and Client resulted in many extra reworks on site.</p> <p>The Contractor underestimated the work required and no appropriate construction actions or work plan have been produced.</p>	<p>design.</p> <p>A full evaluation of the amended design should have also been undertaken by the Client task force.</p> <p>The adoption of BIM should have facilitated the coordination of the design changes across all disciplines.</p> <p>Detailed simulation of the construction process should have been carried out to ensure that problems are “eliminated” prior to construction.</p> <p><b>Challenges</b> Construction was underway when this decision was taken, making changes expensive to undertake.</p> <p>The existence of non-collaborative environment made it difficult to create a Client-led task force to manage the design amendments</p> <p>The contractual agreements (traditional procurement) prevented individual partners from taking the risk to be proactive in finding practical solutions, i.e. each partner was looking after his own interest and NOT the Client's.</p> <p>The lack of awareness and adoption of the latest technology</p>		income equal to 44.4M
--	---	---	--	-----------------------

<p>Improper quality control for the Architectural work</p>	<p><b>Context</b>  The International Consultant adopted extremely high specifications for the finishes; either highly expensive to import or are “unfit” for the local market</p> <p>The time required to approve the submittals was very lengthy in spite of have onsite Consultant's representative</p> <p>In some cases, submittals which have been approved by the onsite Consultant's representative, it was rejected by the Consultant's Head Office.</p> <p><b>Reasons</b>  The lack of clear line of authority made the decision making process difficult and lengthy</p> <p>The role of the Consultants' site supervision was not strictly adhered to, therefore leaving the approval process “loose”.</p> <p>The lack of rigorous and effective QA/QC procedures on site.</p> <p>The lack of long term planning made the time</p>	<p><b>What should have happened</b>  Design specifications should have been evaluated early at the design stage leaving no “surprises” on site; full cost analysis (and possibly life cycle costing) should have been carried out at the design stage to evaluate the impact of the high specifications on the final cost</p> <p>Local Contractors should have participated in producing the final design to ensure that constructability and “fit for purpose” factors are taken into consideration.</p> <p>The adoption of BIM should have provided the Client/Consultant with a tool to quickly carry out cost analysis at the design stage</p> <p>A Client led/approved QA-QC should have been adopted</p> <p>Better control of the supply chain should have provided the Client with better confidence in ensuring that high quality materials would be delivered to site on time and with minimal cost and waste.</p> <p><b>Challenges</b>  The traditional procurement system makes project partners work in isolation which makes each partner look after his own interest.</p> <p>Local culture and practices make it difficult to adopt new approaches that deviate from the norm, particularly with regard to separation of design and construction</p> <p>The lack of awareness and adoption of the latest technology such as BIM to improve construction on</p>	<p>Overlaps</p>	<p>NA</p>
--	---	--	-----------------	-----------

	available for approval of submittals and site delivery very short.	site.		
Waste	<p><b>Context</b> The wastage of the highly specified finishing materials (marbles, granite, timber veneer, etc.) was extremely high.</p> <p>This had high time and cost implications.</p> <p><b>Reasons</b> The contractor assumed that the local practices can be used (he purchased unaccepted materials)</p> <p>The fragmented nature of the traditional purchase procedures and delivery method</p> <p>The lack of rigorous and effective QA/QC procedures on site</p> <p>The lack of long term planning made the identification of materials and waste extremely difficult.</p>	<p><b>What should have happened</b> Local contractors should have participated in producing the final design to ensure that constructability and “fit for purpose” factors are taken into consideration.</p> <p>The adoption of BIM should have provided the Client/designers with a tool to quickly carry out cost analysis at design stage</p> <p>A Client led/approved QA/QC should have been adopted</p> <p>Better control of the supply chain should have provided the Client with better confidence in ensuring that high quality materials would be delivered to site on time and with minimal cost and waste.</p> <p><b>Challenges</b> The traditional procurement system makes project's partners work in isolation which makes each partner look after his own interest.</p> <p>Local culture and practices make it difficult to adopt new approaches that deviate from the norm, particularly with regard to separation of design and construction</p> <p>The lack of awareness and adoption of the latest technology such as BIM to improve construction on site.</p>	NA	(huge wastage has been done)

Problems Related to Local Authority's Requirements				
Insufficient car parking	<p><b>Context</b> Due to the change in the use of the building plus the introduction of the plaza enclosure, it was realized that there was a shortfall in the minimum numbers of cars parks.</p> <p>Extra car parking were provided at the basement plus an adjacent new land was acquired to accommodate the required extra car parking</p> <p><b>Reason</b> This is mainly done to satisfy the Local Authority requirements.</p>	<p><b>What should have happened</b> The problem should have been made easier to deal with if a BIM model was produced for the building. Designers would have the ability to optimise/simulate the car parking spaces</p> <p>Through BIM, the Client and the Consultant would have discovered the problem early and would have provided a solution earlier without causing significant delays.</p> <p><b>Challenges</b> The local market lacks the awareness of the latest technology such as BIM</p> <p>The Client seems to have a relaxed role in controlling and monitoring the process of the design amendments.</p>	Not known	200M (An estimate by the PM to construct an additional car parking)
Reinstatement of external roadwork	<p><b>Context</b> Due to the changes of use of the building, the external roadworks needed to be reinstated.</p> <p>This had caused further approval from the local authority which led to further costs.</p> <p><b>Reasons</b> Unfamiliarity of International Consultants with the Local Authority requirements</p> <p>Lack of continuous consultation with the Local Authority</p>	<p><b>What should have happened</b> With BIM, the Consultant would have model the external roadwork for the Local Authority, thus improving the communication between the Client and the Local Authority. Through BIM, an earlier solution would have been made possible.</p> <p><b>Challenges</b> International Consultants are unaware of the Local Authority requirements.</p> <p>The local market lacks the awareness of the latest technology such as BIM.</p>	NA	2.5M (Allowance made by the PM should the work go ahead)



<p>Metering strategy and connection of utilities</p>	<p><b>Context</b> The mix use of the project (residential and commercial) introduces different types of monitoring the use of utilities (mainly electricity and water).</p> <p>A metering strategy therefore needs to be in place at early stage of the project as it could have an impact on construction and utilities' connection.</p> <p>In addition, this strategy has to be approved by the Local Authority. This approval has delayed project by six months.</p> <p>This has resulted in delays and change of work scope which resulted in further claims.</p> <p><b>Reasons</b> Operations and maintenance of the project was not considered at the design stage</p> <p>The change of use has affected the supply of utilities to the project. The latter was not considered at the time of change of use.</p> <p>There was insufficient consultation between the Consultant and the Contractor with the Local Authorities at the appropriate times.</p> <p>Change of local regulations (Green building regulation was imposed)</p>	<p><b>What should have happened</b> A proposal for a metering strategy should have been produced along with the detailed MEP design.</p> <p>Consultation with the Local Authority should have been sought on a continuous basis, both at design and construction stages.</p> <p>The metering strategy should have been one of the tasks that needed to be addressed as part of the impact of design and its amendments on use of utilities.</p> <p><b>Challenges</b> The unawareness of International Consultants of Local Authority's requirements</p> <p>The lack of involvement of local contractors with the international consultants makes it difficult to address such details at the early stages of the project.</p> <p>Details such as metering strategy normally left to contractors to perform ignoring the impact it might have on project delays or site reworks.</p>	<p>6months</p>	<p>Loss of income equal to 88.8M</p>
--	---	---	----------------	--------------------------------------

### 7.3.4 Estimated Impact: Cost and Time

Further information was collected from the project management company in an attempt to measure the impact the above had on both time and cost. The time delays were converted to “loss of income”. Table 7.3 shows the outcome. It can be seen that although there was extra costs related to the change of use and the addition of the Plaza, the loss in income due to the incurred delays are far more significant. This implies that if these changes were effectively addressed with strict quality control procedures, where delays could be minimized, the cost implication would have been significantly reduced.

Table 7.3: Cost and Time Implication on the Project

Category	Time delays (Months)	Cost implication (Million UAED)	Loss on income (Million UAED)
MEP Design Related Problems	19	5.0	280.6
Introduction of the Plaza	Overlaps	102.3	-
Architectural and Structural Design Related Problems	6	28.0 75m (saving)	74.0
Problems Related to Local Authority's Requirements	6	202.5	88.8
<b>Total</b>	<b>31</b>	<b>337.8</b>	<b>443.5</b>

In addition, an attempt was carried out to categories all the above listed problems with a specific focus on BIM, IPD and client leadership role, as identified under the “what should have happened” section. The aim was to estimate the impact that these collective factors could have had on the project. Table 7.4 shows that the estimated total cost impact of these three factors is approximately 568 million UAED. This value is about 39.5 percent of the estimated total cost of the project.

Table 7.4: Estimated BIM/IPD Impact on the Project

Factors	Cost Impact UAED (Millions)	Time Impact	Loss of income UAED (Millions)	Total cost UAED (Millions)
BIM, IPD & Client Leadership	198	25	370	568
Estimated project cost	1,438			
<b>Percentage impact</b>	<b>39.5%</b>			

This result is very much in line with the Investor Report (BIM Task Group, 2012) which proposed that there is a potential of 40% saving if BIM is used at the “tender” and the “construction” stages through:

- a. The coordination of the contractor design information.
- b. The delivery of coordinate information to the construction team and the use of 4D (construction simulation) which offers clear understanding to package contractors.

Hence, this study can be considered as one of the first cases to demonstrate this type of saving by using BIM/IPD associated with strong Client leadership.

Careful study of the above problems which occurred during the design and construction of the projects clearly demonstrates that the combinations of BIM/IPD with a high level of collaborative are becoming increasingly important for large and complex projects. This approach is clearly indispensable for such projects not only for the UAE but also around the world.

This case study clearly shows that the project does not lack the technical expertise and skills (represented by internationally recognized and among top firms worldwide Consultants, Project Management Companies and Contractors). What makes a difference is the leading role of the Client, who can lead on the use of BIM/IPD within a collaborative environment supported by highly qualified Client's staff with positive attitude of delivering the best.

## **7.4 Case Study Two**

### **7.4.1 Project Description**

The project is also a mixed-used development, residential with commercial space, which consists of twin towers of 21 residential floors each connected through four podiums, a ground floor and three basements. It will accommodate 250 units of residential apartments, swimming pools, children's playgrounds, a mixed-use gymnasium and 459 parking spaces. The total cost of this project is around 360

million UAED (\$100Million) with a total built up area of 90,000 squared meters and almost 5,000 squared meters of retail space.

The project witnessed the first IPD delivery in the UAE where the maturity level of the local construction industry to deliver projects with IPD approach is very low. All project stakeholders including the facilities management company are on board from the start. The selection of preferred main contractor and MEP subcontractor were made at the early design stage and a three-way design evaluation: cost, time and constructability are done at various intervals of the design process. In this case study, BIM/IPD is implemented whereby the client organisation played a significant role on leading the process. The client employed a BIM/project management company to:

- a) Manage the implementation of BIM/IPD from design to construction;
- b) Provide training to all stakeholders to bring them to the right maturity level;
- c) Introduce BIM standards to ensure a smooth information exchange between the different stakeholders; and
- d) Assist in setting up the IT infrastructure to support full collaboration.

The study was conducted at a time where LoD300 (detailed design) was completed, the main contractor was already on-board and the enabling works had started. This case was selected to verify the various components of the proposed process protocol. Questionnaires were developed and semi-structured interviews were conducted with the client's representative, consultants and contractors. The interviews were conducted to capture their views towards the BIM/IPD process and to ensure that the detailed description of each process was valid and comprehensive. Hence, these interviews were focused on validating the various components of the process protocol throughout the project's lifecycle.

## EXPLORATORY ACTIONS ON CASE STUDIES TWO AND THREE

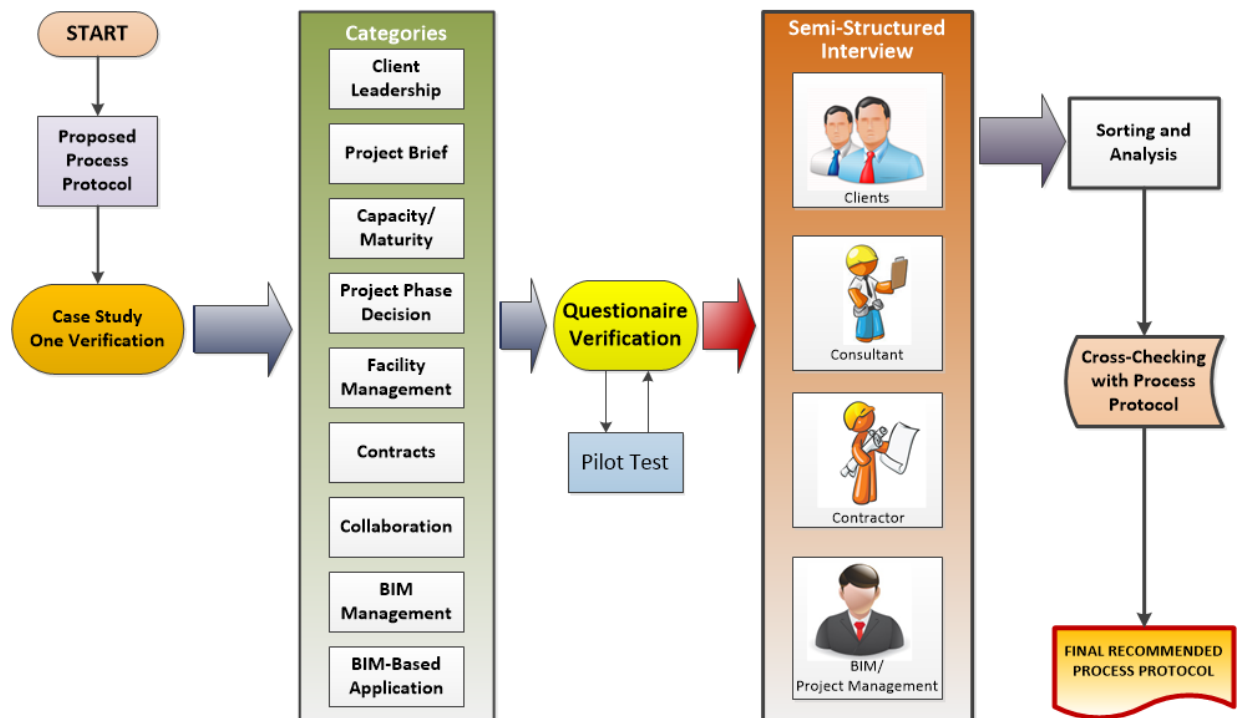


Figure 7.3: Approach to Case Study Two and Three

### 7.4.2 Approach to Case Study Two

Figure 7.3 shows the methodology used to conduct this case study. The following steps were taken:

1. General questionnaires were drafted by referring to the proposed process protocol which was verified through case study one's findings.
2. The questionnaires were designed with reference to the nine criteria which underpin the various stages of the process protocol (Figure 7.3).
3. The questionnaires were verified by a pilot test to verify the suitability of the proposed questions and their reflection to the proposed process protocol.
4. Semi-structured interviews were carried out with each project stakeholder separately and all information was recorded and documented.
5. All the answers gathered were analysed and compared against each other.
6. The information obtained was then cross-checked with the processes of the process protocol's specific phases and all the decisions made at each phase.

7. The process protocol was then modified accordingly.

As shown in Figure 7.3, nine categories have been used in the development of the questionnaires. These nine categories were determined from the findings of case study one. After further analysis of the various processes of each phase of the process protocol, it was found that these nine aspects underpin the entire processes. As such, it was decided to use these criteria to guide the design of the questionnaire and data collection for Case Studies Two and Three.

The nine categories are explained in detail as follows:

### **(1) Client Leadership**

This criterion is related to the involvement of clients from the early phases to the completion of the project. The role of clients is to ensure project completion on time and within budget. The objectives of this criterion are:

- ✓ To verify the importance of client leadership in the project
- ✓ To verify clients' roles and responsibilities
- ✓ To verify the critical processes, i.e. where and when client leadership should be performed
- ✓ To verify the appropriate deliverables from client leadership processes

### **(2) Project Brief**

This criterion is related to the process by which client requirements are investigated, developed and communicated throughout the project to produce an effective project brief. The objectives of this criterion are:

- ✓ To verify the importance of project brief
- ✓ To verify the appropriate phase(s) and the stakeholders involved
- ✓ To verify the importance of project stakeholders to understand the project brief

### **(3) Capacity/Maturity**

This criterion is related to the capacity, or the ability to perform a task, deliver a service or generate a product using BIM. Whereas the maturity referred to the ability of the project stakeholders to understand the importance of BIM and their participations in BIM development. The objectives of this criterion are:

- ✓ To verify the levels of understanding and appreciation of project stakeholders of BIM/IPD
- ✓ To verify the capacity of project stakeholders on using BIM/IPD
- ✓ To verify the interest of project stakeholders on using BIM/IPD

### **(4) Project Phase Decision**

This criterion is related to the decision which has to be made in order to proceed to the next phase. This decision is made based on data and feedback produced from the processes as the deliverables at the end of each phase. The objectives of this criterion are:

- ✓ To verify the importance of feedback from the project stakeholders at the end of each phase
- ✓ To verify what data are produced and need to be recorded after each phase

### **(5) Facility Management**

This criterion is related to the involvement of the client's FM department at the early phases of the project in planning and providing all FM requirements to be accommodated in the project brief and BIM requirements. The objectives of this criterion are:

- ✓ To verify the need of the client's FM department early involvement in BIM/IPD related project
- ✓ To verify FM requirement plans as additional information for project brief and BIM which are essential in the operation and maintenance phase (LoD500)

## **(6) Contracts**

This criterion is related to contract procedure according to the selected collaboration level. The objectives of this criterion are:

- ✓ To verify the effect of conventional contracts on the application of BIM/IPD
- ✓ To verify additional information or requirements for BIM/IPD related project

## **(7) Collaboration**

This criterion is related to the collaboration of all project stakeholders such as their collaborative involvement at the design phase, the problems they face and the suggestions to improve the collaboration. The objectives of this criterion are:

- ✓ To verify the importance of collaboration among project stakeholders
- ✓ To verify who should initiate the collaboration process
- ✓ To verify BIM development processes in the collaborative environment
- ✓ To verify the effectiveness of the early involvement of all project stakeholders in the BIM development process
- ✓ To verify the issues and problems that can be improved in a collaborative environment

## **(8) BIM Management**

This criterion is related to the management of BIM plans including the roles and responsibilities of all project stakeholders and the use of BIM standards. The objectives of this criterion are:

- ✓ To verify the need for a designated client's BIM office for effective BIM management
- ✓ To verify the essential roles and responsibilities for effective BIM management
- ✓ To verify the essential processes for effective BIM management
- ✓ To verify which phases are suitable for BIM management processes
- ✓ To verify the importance and the use of BIM standards



## **(9) BIM-Based Application**

This criterion is related to the use of BIM related software, IT infrastructure for BIM development and training. The objectives of this criterion are:

- ✓ To verify the importance of BIM-based application investment including software and hardware
- ✓ To verify the essential procedures for selecting the appropriate BIM-based applications
- ✓ To verify the effectiveness of BIM-based application training for BIM development – the suitability, duration and budget

### **7.4.3 Interviewees' Background**

Several semi-structured interviews were conducted with selected staff from the projects; including representatives from the client committees, consultants and contractors.

#### ***a) Client Committee Representatives***

Two client committee representatives were interviewed to give their views and to verify all the categories used in this case study. The first representative was a highly qualified structural engineer with more than 30 years of experience of designing and managing large and complex projects in the UAE. He is referred to, as Client A. The second representative is a highly qualified accountant with more than 30 years of experience and has vast experience in the construction industry. The latter, referred as Client B, had the added advantage of verifying some of the non-technical aspects, which were required to strengthen the process protocol.

#### ***b) Consultant A***

This consultant is the lead consultant who is responsible for the design development of case study two. The company is a well-established multi-disciplinary consulting firm with vast experience in building designs for leisure, commercial, residential, industrial and retail sectors internationally. The interview was conducted with two

representatives, i.e. the project manager and the senior architect. They will be referred to as Consultant A.

**c) Consultant B**

This consultant represents two qualified MEP engineers from the same company as Consultant A. The interview was conducted to gain their views on some aspects of the criteria especially on their collaborative involvement and issue of clash management while developing BIM models. They will be referred to as Consultant B.

**d) Consultant C**

This consultant is the BIM and project management consultant from the company, which is responsible for the implementation of BIM in design and construction as well as the adaptation of BIM to improve project management practices. Consultant C was represented by a qualified BIM Manager with more than 20 years of experience in CAD and BIM development who is fully in-charge of BIM implementation in this project.

**e) Contractor A**

Contractor A is the main contractor who is responsible for constructing the project. The company was part of a group of companies with vast experience in construction, oil and gas projects. The company has a work force of more than 60,000 people with approximately 1,200 professionals in such disciplines as engineering, surveying, planning, project management, construction managing, cost control engineering, finance and accounts, who have considerable international work experience.

The interview was conducted together with a number of representatives from Contractor A including the General Manager, Design Manager, Contract Manager and Account Manager. They shared their views on the questionnaire during the interview session.

#### **7.4.4 Case Study Two's Findings**

Case Study Two was selected as an IPD delivery method, but with level two of

collaboration (as discussed in section 3.9) due to the difficulties of performing multi-party contracts. The interview was conducted with a focus on nine categories as mentioned in section 7.4.2. The interviewees include the client committee representatives, the lead consultants with the MEP engineers, BIM and project management consultants and the main contractor.

The findings of this case study are listed below according to the nine criterion.

### **Client Leadership**

- It was clearly indicated that client leadership is considered to be very important to defining the vision and direction of projects by providing a detailed and clear brief. Both consultants and clients pointed out that setting up a client committee with appropriate roles and responsibilities is essential. This committee was recommended to be setup at the very early phase of the project.
- The consultants highlighted that client roles and responsibilities should cover the capability to handle and resolve design and construction issues as well as to give support on BIM development and project management. While contractors were slightly conservative as they were mainly working with the consultants and had no direct communication with the client. However, this issue was highlighted by the management company who stressed that the client's roles and responsibilities should be made clear to all parties.

*“The client should interact with other project stakeholders in a collaborative way, have fast decision-making on the major item, facilitating the approvals of the local authorities, having a clear procurement strategy and selecting the most qualified partners in a professional way” – Client B*

*“The client committee should participate in the formulation of BIM Management Plan for each project, so that all parties understand what to expect from the others as well as what is expected of them.” – Consultant C*

- The experience developed by the client during the execution of this project led to the conclusion that there is a clear need to manage BIM development across the various parties through a specialized department. This was also stressed by consultants who had highly recommended that client organisations should have a separate section or department to manage and monitor BIM implementation:

*“For continuous and long term projects, it is beneficial and recommended to have a separate department for the client organization.” – Client B*

*“This is a highly specialized type of work and directly related to IT. This will ensure the development of a coordinated and consistent BIM through the deployment of standards throughout design and construction.” – Client A*

*“For large client organisation, it is highly recommended to manage BIM implementation.” – Consultant A*

### **Project Brief**

- Both clients and consultants highlighted that the project brief is a very important aspect that needs to be considered at the very early phase of the project. The consultants stressed that client organisations should create the project brief which should be clear and comprehensive and include elements of design brief, BIM requirements, budget and time factors.

*“Throughout the life of the project, BIM requirement should include the vision, value added applications, deliverables, etc. for each stage of the project.” – Client A*

*“BIM requirements should have clearly been defined in the project brief.” – Consultant A*

- The consultants stressed that in current practices, project briefs are inadequate. They highly recommended that the project brief should be concerned with the quality of materials, life cycle, BIM and other related construction documents. The project brief should also cover the scope of the project to be achieved, when the project should be constructed and occupied along with an estimated budget.

*“The current brief is inadequate. The design consultant is charged with bringing back their best guess at a building mass and functional relationship of spaces that may or may not work on the project site. Code requirements for the design are only subjectively applied based on the designer’s experience with reviewing authorities.” – Consultant C*

- Both clients and consultants suggested that the project brief should involve decision makers, i.e. the client committee and client experts/advisors. It is recommended that the client’s committee and FM department should review the project brief and its compliance with FM requirements.

- The Consultant highlighted that when using BIM, a report can be generated from BIM listing all spaces and their areas can be validated against the functional requirements of the project brief.

### **Capacity/Maturity**

- Both clients and consultants stressed that BIM capacity/maturity is important and there should be a balanced expectation among members of the client committee with regards to BIM outcomes and benefits. Achieving such a balance would be based on experience, BIM's qualifications and maturity:

*“General knowledge of BIM is essential for the client committee which can lead to a good appreciation, support, fast action and approval.” – Client A*

*“The client committee is composed of members with different areas of interest: architectural, structural, MEP, financial and legal issues. The client committee's understanding of the impact of BIM on delivery methods should be focused on these areas of interest.” – Consultant C*

- The experience gained by the client and consultants through the on-going projects indicated that BIM capacity/maturity can be increased and measured through a number of interactive specifically designed workshops as well as through continuous educational programs and the development of BIM maturity criteria.

*“It is also useful to study similar successful projects in other country and to analyse the key success factors.” – Client A*

*“BIM capacity/maturity can be achieved through interactive discussion, previous experience, BIM's qualifications and BIM maturity criteria” – Consultant C*

- With low maturity levels in BIM development, the client, consultants and contractor gave mix responses on the use of BIM. Some members of the client committee highly appreciated BIM and had high expectations for delivering the project on time to cost and to a high quality. Yet other members look at BIM as a painful change with no clear vision of the benefits. On the other hand, there was an understanding from both the consultant and contractor to raise their BIM capability to enable them to deliver better outcomes.

*“We understand that this is a giant step which needs preparation, highly qualified staff and time to reach the desired level. Some compromise has to*

*be accepted regarding the level of BIM staff and the limitation of IT, but without forgetting the final aim.” – Client A*

*“Limits in the capability of current software available for the development of BIM require this segregation of purpose. BIM should be utilized so that it is “fit for purpose” to support a proper site feasibility study to assist in the preparation of the initial project brief.” – Consultant C*

*“We have increased our manpower, selected the right people and started to equip them with BIM training to increase their capabilities and knowledge on BIM.” – Contractor A*

- The Client stressed the need of a highly qualified staff with BIM experience to realize the benefits of BIM. It was highlighted that this can be done internally by training existing staff or it could be acquired from outside the organisations. While the consultants appreciated the skills required to develop BIM not only to meet the design requirements but also those related to construction and FM.

*“Define promotions and incentives program for the staff plus creating R&D department are suggested to improve BIM capabilities.” – Client A*

*“We have not taken steps to expand BIM capacity or capabilities. We lack sufficient staff and supporting infrastructure to meet expanding requirements in the transition from the design stage of BIM to the construction stage of BIM to turnover of a As-Built BIM and BIM for Facility Management.” – Consultant C*

### **Project Phase Decision**

- Data and previous records are important elements that need to be archived for future use especially for asset management, operational and maintenance purposes. Clients, consultants and contractors recommended that all data is to be recorded and feedback reports should be produced at every phase of the project for future use. These include project progress report, problem areas and resolution.

*“Dimensional criteria are most important during the design. Other data specific to materials and manufacturing can be incorporated during construction.” – Consultant C*

*“Project feedback is a benefit to all parties” – Consultant C*

- It was suggested that the recording task and feedback report should be performed by BIM and the project management office. Geometric data is typically created by

the design consultant while performance and manufacturer data is collected during construction and should be recorded by the contractor.

### **Facility Management**

- All parties indicated that BIM implementation should be linked to FM requirements at the very early phases of the project. This should involve the client organisations, BIM consultants and FM departments.

*“The requirements of FM need to be assessed to determine an acceptable level of support by BIM for their needs” – Consultant C*

- It was indicated that basic FM requirements should cover all local authorities' requirements, such as “Estidama”, and should be an integral part of the project brief. (“Estidama” means ‘sustainability’ in Arabic for building rating systems used in the Abu Dhabi region).

*“FM requirements are essential and should be done in a cooperative environment. The final goal of delivering the project in the best quality, appropriate time and cost should be the governing factor of the behaviour of all partners involved” – Client A*

*“FM needs can be outlined in the BIM management plan and in the contract specifications.” – Consultant C*

- The contractor stressed that an MEP selected system for cost, operation and easy maintenance may be the most important factor for buildings' performance over their life. Hence, lifecycle should be an essential element when considering design alternatives such as cooling systems.

### **Contracts**

- The project goal was to have a multi-party contract aimed at collaboration level 3, but it was difficult, at that stage, for public organisations due to local regulation. Therefore, collaboration level 2 was accepted which had multi-contracts with reference to each other and a common responsibility matrix.
- The client was fully aware of the constraints imposed by current contractual agreements and recognized that the right selections of consultants/contractors should be based on value-added rather than the lowest bid price, thus awarding contracts to the most appropriate consultant, sub-consultants and contractors.

- As the contractor was expected to work closely with the consultants with the aim of improving the design and reducing the construction time. Yet at the same time he felt that he was working under a fixed time to complete the project. Justifiable extensions do not count against contractors so there is no advantage for contractors to work towards reducing construction time schedules, while doing so incurs huge man-hour costs in planning. The contractor suggested that incentives to encourage early completion are desired if they can reduce the construction period.
- It was highly recommended to prepare an assessment method to measure the maturity of consultants and contractors including their internal implementation levels of BIM and associated management processes. Such an assessment method could assign levels of preference to the pre-selection of teams (consultants and contractors) prior to the initial design, allowing for a true IPD.
- Both the client and consultant stressed that the work's progress should be constantly monitored. They agree that progress reports should be submitted to the client committee highlighting any urgent requirements that might deviate the project from the plan.
- Both the consultant and contractor agreed that there is not much difference between a conventional contract, with or without BIM requirements, except some additional information relating to BIM such as a BIM implementation plan.

*“BIM (Models) can be used as a source of reference in addition to the traditional contract documents, but do not include the range of project requirements that are represented in the full set of drawings and specifications.” – Consultant C*

*“All the requirements for the implementation of BIM/IPD should be included in the contract where all stakeholders will be bound and their roles and responsibilities clearly defined.” – Contractor A*

### **Collaboration**

- It was observed and agreed by all project stakeholders that the level of collaboration will determine the type of contract selected where the level of collaboration should be determined at the very early phase of the project.

*“Collaboration should happen at the early phase of design including clash management issues.” – Consultant A*



*“Our practice in this project showed that client leadership and client intervention are essential for moving forward during all the process protocol phases.” – Client A*

*“The concept can be adopted by the consultant but the most important issue is that other stakeholders should also adapt to the same concept.” – Consultant A*

*“Our involvement at the early stage of MEP design gives us more ideas and suggestions on the type of materials to be used. The discussion is very useful and giving us more practical insight into what will actually happen later on-site.” – Contractor A*

- The client agreed that the collaborative environment is new to most clients in the region while outcomes depend on the attitude of staff. Collaboration should be facilitated by client organisations by setting milestones against the agreed deliverables and periodically reviewing the project's progress.
- During BIM development, the consultants thought that utilizing BIM would prepare them for “clash free” designs. They were wrong. It became apparent to all parties that the number of clashes were very much similar to those encountered in traditional design approaches which were normally handled during construction by contractors.

*“Collaboration is a must for MEP even when working in conventional way to resolve some issues with the architecture and structure.” – Consultant B*

- Both the consultant and contractor indicated that early involvement of all project stakeholders, especially the contractor, is very important. Many issues such as constructability, value engineering and material selection can be done in a flexible way with no additional cost or delay.

*“The involvement of the contractor was helpful, but limited as no one really wants to change construction techniques. Their assistance was helpful during clash resolutions in recognition that any simplification of construction or reduction of clashes represents a greater profit margin to the contractor in a lump sum contract.” – Consultant C*

*“Roles and responsibilities should be clearly defined. What to do and how much to do?” – Consultant A*

- Both consultants and contractors agreed that high-level design reviews by the client's expert staff were very useful during the design stage. The client has to

monitor the design production in order to avoid any surprise delay and painful problems.

- Based on current project experience, the consultant stressed that collaborative environments such as Bentley ProjectWise<sup>®</sup> were very useful to provide an independent document repository. These systems could be tailored to suit the project requirements.

### **BIM Management**

- BIM/IPD were new to most of the project stakeholders and all agreed that BIM management is essential at the present time especially when the maturity levels among partners are low. The role of BIM management, at this level of maturity, should focus on providing assistance to different parties to develop BIM. This role should shift toward the BIM management process when the maturity levels of the other partners become adequate.

*“The BIM management process can be improved by creating a R&D department for monitoring the performance, recording the experience and planning for the future” – Client A*

*“BIM management helps us understand BIM better and to coordinate all the project stakeholders on BIM implementation” – Contractor A*

- All the project stakeholders agreed and stressed that BIM management should setup BIM standards to be used in the development process. This is mainly to allow for full interoperability (data exchange between different software systems) and have a full capability to review/visualise any building element/system of the model. BIM Standards should be determined and delivered in connection with the BIM management plan at the pre-concept stage of design.

*“BIM management can follow the international BIM standards and impose their use in the BIM development process.” – Client A*

*“BIM management should provide more guidelines and advice for better BIM implementation.” – Consultant B*

*“The importance of BIM standards becomes clearer across multiple projects as the consistency of delivery is maintained, and the ability to deliver expectations and review submissions is facilitated.” – Consultant C*

*“For multi users, we need to set a standard. What we want from BIM and what we can develop from it so that information from BIM can be shared.” – Contractor A*

- Clash management is one of the advantages of using BIM. However, due to the lack of capability of handling this issue, the consultants highlighted that the BIM management service was essential in helping this process and should not lack the technological knowledge and level of proficiency.

*“BIM management plays an important roles in clash management.” – Consultant A*

*“Very important especially on coordinating the clash management. A series of workshops lead by BIM management consultants are essential to resolve the issues.” – Consultant B*

- Both consultants and contractors agreed that sufficient staffing and resources (software and hardware) in support of documented goals are mandatory for improving BIM management processes.

### **BIM-based Application**

- Both client and consultants agreed that client organisations should understand the importance of BIM-based applications and the applications that needs to be developed on top of BIM to evaluate the project at the various design and construction phases such as cost estimate, BoQ, ROI, energy analysis, clash detection, etc.

*“In the future each consultant will have his own BIM system, and the BIM system can be one of the factors in selecting the consultant.” – Client A*

*“There are applications which are required to facilitate the achievement of the brief components.” – Consultant C*

- The Client has clearly recognized the role that client organisations should play in order to maximize BIM benefits. This should include clients’ technical, financial and legal departments. They should be aware of BIM delivery methods and should facilitate the deployment of BIM as related to their disciplines.

*“Appreciation by the top management but different perception by other staff.” – Client A*

- Through the experience developed from this project, both consultants and contractors highlighted that the setting up of IT infrastructure for BIM based applications added more cost, but the cost could be justified if the real benefit was clear to the client and the applications can proof it. The cost of mistakes in construction is very high and painful, thus the initial cost of improving construction can be very well justified, but it is not clear to all members.

*“The measurement of BIM development costs is difficult to be justified for first time BIM projects but we are sure the savings can be made later in future BIM projects.” – Consultant A*

*“The time saving on clash management issues is obvious. This will reduce the whole project cost especially during the construction period.” – Consultant B*

*“The managing authority, the client committee or the contract manager on behalf of the client committee, should determine the appropriate IT infrastructure based on goals for BIM and collaboration.” – Consultant C*

*“There are some problems at the beginning of the project due to additional investment, configuration, training and understanding of the requirements for BIM-based development.” – Contractor A*

- Consultants and contractors had mixed reactions on the use of new BIM-based application especially the requirements of new knowledge, trainings and skills.

*“There are positive thoughts and some excitement among staff to learn new technology and skills. Training enhances the capability within existing experience.” – Consultant A*

## **7.5 Case Study Three**

### **7.5.1 Project Description**

Case Study Three is another high rise mixed-use development which is 153 meter high with 5 basements, a ground floor, a mezzanine floor, 3 podiums, a mechanical floor, 32 residential levels and a service roof. Although the development consists of a single mass, there are vertical massing breaks in the façade to give an illusion of three towers. It will accommodate 368 units of residential apartments, swimming pools and a mixed-use gymnasium with 585 parking spaces. The total cost of this project is around 530 million UAED (\$150Million) with a total built up area of 132,000 squared

meters and almost 2,000 squared meters in retail space. The lead consultant was responsible for the architecture and structure designs only and the MEP sub-consultant was recruited to produce the MEP design. The preferred main contractors were invited to evaluate the design where coordinated and clash free BIM were given to contractors at the tender stage.

Case Study Three is specifically selected to strengthen the findings of Case Study Two where a collaborative environment is established at the end of the schematic design. Case Study Three was conducted when LoD300 had been completed and the main contractor had just come on-board.

This case is another on-going project, which has implemented BIM right from the early stages of the design phase but with different levels of collaboration among the project stakeholders. It was selected to ensure that the proposed process protocol was effective and could be validated at different levels of the collaboration particularly in competitive tendering environments. Questionnaires were developed and semi-structured interviews were conducted with the client's representatives and consultants. The interviews were conducted to capture their views towards the process and to ensure that detailed descriptions of each process are valid and comprehensive. Therefore, these interviews will focus on validating the various components of the process protocol throughout the project's lifecycle.

### **7.5.2 Approach to Case Study Three**

The aim of this case study is similar to that of Case Study Two, i.e. to validate the proposed process protocol but under different levels of collaboration. Hence, the adopted approach to conduct this case study was similar to the approach used in Case Study Two. The same questionnaires, based on the nine categories, were used in these semi-structured interviews with client's representatives and consultants, as shown in Figure 7.3. The following steps were taken:

1. Semi-structured interviews were carried out with each of the project stakeholders separately and all information was recorded and documented.

2. All the answers gathered were analysed by comparing them with the answers given by all project stakeholders.
3. The information obtained was cross-checked with the processes, the process protocol's specific phases and all the decisions made at each phase.
4. The process protocol was modified to capture the feedback from stakeholders.

### **7.5.3 Interviewees' Background**

Several semi-structured interviews were conducted with selected qualified staff from the projects; including representatives from the client committee, consultants and contractors. Case Study Three's interviewees consisted of the lead consultant, the MEP sub-consultant, the BIM and project management consultant. The contractor had just come on-board when Case Study Three was conducted and was not included in the interview. Further information on the interviewees is provided below:

#### ***a) Client Committee Representatives***

Two client committee representatives have been interviewed to give their views and to verify all the categories used in this case study. The first representative is a highly qualified structural engineer with more than 30 years of experience in designing and managing large and complex projects in the UAE and he is referred to, as Client A. The second representative is a highly qualified accountant with more than 30 years of experience and has vast experience within the construction industry. The latter, referred to as Client B, added an advantage in being able to verify some non-technical aspects, which were required to strengthen the process protocol.

#### ***b) Consultant D***

This consultant is the lead consultant and it is the architectural and engineering design firm who are responsible for the design development and supervision of the project. The company was established almost 30 years ago and has long and vast experience in high-rise commercial projects. The company was also recognised as a global multi-disciplinary practice and is ranked as one of the top three firms regionally, and in the top 50 firms globally as rated by leading industry publications and their peers. The

interview was conducted with a qualified and experienced project manager of the company who will be referred as Consultant D.

***c) Consultant E***

This consultant is the appointed MEP sub-consultant who is responsible for the MEP development of Case Study Three's project. This consultant is an international company and one of the world's leading engineering and design consultancies with 14,500 employees, based in more than 300 offices, across 35 countries, on every continent. The interview was conducted with a qualified BIM Manager who is responsible for the MEP/BIM implementation project of Case Study Three.

***d) Consultant F***

Consultant F is a qualified BIM Manager from the same company as Consultant C with more than 5 years of experience in BIM development who was fully in-charged of BIM implementation in Case Study Three's project.

#### **7.5.4 The Outcomes of Case Study Three**

Case Study Three has been selected where the lead consultant was separated from the MEP consultant and the preferred main contractors were invited to evaluate the design at the tender stage. The interviews were also focused on the nine criteria as mentioned in Section 7.4.2. The interviewees include representatives from the client committee, the lead consultants, the MEP sub-consultant and the BIM and project management consultant. As the contractor was brought to this project at a late design stage, it was felt that the gained benefits to the research would be minimal. Therefore, they were excluded from the interviews.

**Client Leadership**

- It was also clearly indicated that client leadership is very important and critical for the successful execution of the project. Based on the current project, the consultants clearly highlighted that the clients need to set the parameters on which all the other stakeholders need to perform to in order to meet the standards.

*“Client leadership is very important. However, clients need to understand all the requirements and give support in all aspects including additional BIM budget and project management.” – Consultant D*

- The experience developed by the client on selecting the right consultant and contractor highlighted the need for clients to have a clear brief, understand the construction needs, make quick decisions, consider value engineering, consider life cycle costs and not to focus on the lowest initial cost.
- The client also expressed the need to have a clear picture on the overall expectations and deliverables for design and construction. Early involvement and leadership provided by the client, in terms of decision-making on the key milestones, have proven to be extremely advantageous to the project. An active and proactive client is always going to add value to the project.

*“The client’s leadership is always important, regardless of the size and cost of the project. It is the client that sets the success factors, based on which the designers/contractors work to manage those expectations” – Consultant F*

### **Project Brief**

- The consultants stressed that the project brief is critical. Without a project brief, the design consultants would not know what direction the project design would take. It also helps the client articulate his goals/aims from the project.

*“A project brief should be based on the project’s feasibility and outline clear project requirements including design and BIM.” – Consultant D*

- It was recommended by the consultants that the project brief needs to be prepared at the very early phases of the project. Later, it can be modified or updated at different stages depending on the change in the client’s needs.

*“We will be ready sooner with regards to implementing BIM if we receive the project brief including BIM at the very early phases of the project.” – Consultant D*

*“The project brief can be reviewed if the clients’ needs change owing to their review of the program requirements or the consultants’ proposals for a better scheme.” – Consultant F*

- The consultants also highlighted that the project brief has to include design intent of the building; functional requirements; approximate budget of the project; any site



logistics to be considered; and all miscellaneous items that would impact the design/construction of the building.

- The consultant stressed that the requirements listed in the project brief could be directly related to BIM development by the BIM management company using their experience in the type of software required.

*“The BIM Implementation plan would be derived from the project brief by understanding the client’s requirements and implementing/adjusting the BIM strategy accordingly.” – Consultant F*

### **Capacity/Maturity**

- The client expressed that their current BIM capacity is limited, as they have no prior experience with BIM projects. However, direct involvement of the client throughout the project, improved their understanding of the process which has been visible as the project progressed.
- If the projects are going to implement BIM in any capacity, it was suggested by the consultant that clients are preferred to have an understanding of the advantages of the process. This way they can drive their expectations from the project accordingly.

*“Each member of the client committee does not need to be an expert on BIM, as long they have members who can explain the objectives to others.” – Consultant F*

- While clients’ BIM capacity can be reflected by what they understand from the whole process and what their expectations are from each deliverable; it was highlighted that the consultants have to be more conversant in the software and its utilities.

*“Recording the client effect through the project and asking BIM experts to evaluate the client organization.” – Client A*

*“We hired the right BIM specialist and it improved our BIM development.” – Consultant D*

*“The ideal way would be to hire a BIM management service at the start of the job, who can assess BIM’s capacity of the consultants before they are appointed.” – Consultant F*

- It was observed both by client and consultants that understanding the client's requirements and the software/staff required to accomplish those goals are critical for improving the capability.

*“The capability can be improved by continuous educational programs and it is also useful to study the similar successful projects in other countries and to analyse their key success factors.” – Client A*

*“The capability improvement is an ongoing process. It can be argued that the company is lacking in a few areas that would guarantee improvement of the staff's capabilities; but at the same time the need to fulfil the client's deliverables and the project milestones is something that has held priority.” – Consultant F*

- The client highly recommended that project management staff need to be more aware of BIM's capabilities so that the process can be better incorporated into the project.

### **Project Phase Decision**

- It was recommended that at the end of each phase that data/BIM files have to be archived at periodic intervals during both the design and the construction stage. For the purpose of FM-BIM, all data embedded in the model (and attached via an external database) would have to be recorded and stored for FM requirements during the project lifecycle. While coordination information and design elements are more important in the design stage; various FM data like asset information and warranty are more important during the construction.
- Both clients and consultants agreed that a feedback/review process would be immensely helpful to keep track of the lessons learned and benefit future projects.

*“This review process should be extended to all stakeholders in order to have a holistic improvement for everyone.” – Consultant F*

- The experience derived from this project, it was observed that BIM Management should manage the whole information management process; while consultants and contractors have to enter the data and information which needs to be collected from various sources.

## **Facility Management**

- It was also observed that FM plays a big part of the overall BIM requirements. BIM, when implemented in its entirety, has FM models as a deliverable at the end of the project. Hence, the FM requirements form a chunk of deliverables and BIM implementation required for the LoD500 stage.
- It was recommended by both client and consultant that it is beneficial to have the FM department involved in the early stages as it would make it clearer to consultants and BIM management on what information needs to be embedded in the model versus the information that needs to be linked to the model via a database.

*“It should be done in a collaborative environment, the final goal of delivering the project in the best quality, appropriate time and cost should be the governing factor of the behaviour of all partners involved.” – Client A*

*“FM requirements, though preferred to be listed down at the start of the job, are not absolutely essential to be detailed in the beginning of the project.” – Consultant F*

- The client agreed and recommended that their FM department needs to be “educated” on the advantages of FM-BIM.

## **Contracts**

- The Client also agreed that the legal departments of client organisations have to be involved, if not responsible, in the preparation of the contract. However, with other factors like BIM and other construction technology coming in, there need to be other people involved in the framing of the contract.
- It was observed that with the advantage of BIM, traditional ways of preparing the contract documents have changed. With the majority of the contract documents coming out of BIM, the models are becoming an intrinsic part of the contract. But are still not complete enough to be considered a contract document.
- It was agreed by both clients and consultants that conventional contracts can be used with BIM; it's just won't lead to full utilization of benefits that BIM can offer. As with any development, a contract needs modification if a better way to proceed with a project comes along.

*“BIM contract has additional information related to BIM. Sharing the same file among stakeholders, well organised design deliverables with an almost clash free, ability to make early decisions based on the virtual model, early and accurate cost estimates, energy saving practice at early stages and more.” – Client A*

- The contract type would determine the level of coordination between the project stakeholders. Therefore, it is very important that regardless of the type of the contract selected, both consultants and clients agree that the collaboration terms are mentioned in the contract including the roles and responsibilities.
- It was also recommended by both clients and consultants that various procedures, improved through BIM, like submittal process or RFI coordination, should be a part of the contractual obligations.

*“Contract procedure or documents can be improved by adding a common responsibility matrix among all contracts between the client and the stakeholder of a certain project.” – Client A*

*“The contractor has to play a major role in the design process and has to assume more responsibility as far as the liability of the contract documents coming out of BIM models are concerned.” – Consultant F*

### **Collaboration**

- The experience gained by clients and consultants proved that working in a collaborative environment is greater for the success of the project; as it establishes a sense of trust between the stakeholders.

*“Collaborative environment is not a new process because most of the time we are working collaboratively. We received positive feedback on the point of making decisions where all stakeholders were aware on the constraints” – Consultant D*

- It was observed that through experience from various projects, human element is the biggest roadblock of working in a collaborative environment. All stakeholders agreed that it is difficult to break down the age-old prejudice of the consultants and contractors not trusting each other. That is why trust is one of key elements for collaboration.

*In current projects, there is no involvement of contractors and suppliers during the design stage. However, for a design and build company, it might have advantages.” – Consultant D*

- On a technological note, both client and consultants agreed that different levels of software proficiency add to difficulties as the expectations from deliverables tend to be different.

*“Mostly related to the technology, most of the BIM software systems are not ready, the second issue is the size of the file if all details are to be included.”*  
– Client A

*“The biggest problem was the learning curve of the designers as it was their first BIM project. The way the BIM models were structured, led to disagreements in the level of coordination needed before the LoD300 stage.”* – Consultant F

- It was recommended by consultants that although the LoD300 drawings were derived from BIM models, several annotations and dimensions were done in 2D format. This might lead to problems during the LoD400 stage.

### **BIM Management**

- Both the Client and consultants agreed that a BIM Management service was an intrinsic part of design development and design management throughout the different design stages of the project. BIM Management played an important role in providing the consultants with feedback on how BIM can assist in the design, and how the design processes can be improved with the help of different BIM software.

*“It is a new concept, but our practice through this project shows it is very important.”* – Client A

*“It is highly beneficial for the project to have client representative BIM management to monitor the process.”* – Consultant F

*“BIM management lends credibility to the BIM process by acting as a neutral manager guiding the workflows and deliverables of the designers and contractors.”* – Consultant F

- It was agreed and recommended that the role of BIM management services should be the following: set BIM standards; make the BIM implementation/execution plan; ensure the consultants/contractors update the models regularly; have regular workshops/coordination meetings with all project stakeholders; ensure all BIM models translate into proper contract documents; monitor the construction onsite as per coordinated BIM model and make sure all related requirements for LoD400 and LoD500 development are performed.

*“It still needs more time to take shape, but we can say it is related to the maturity levels of other partners (especially consultants and contractors). They need help in training and modelling in the first projects, but like this project, it tends more towards the management and planning. As the maturity level rises up, the partners tend to have more experience in BIM modelling.” – Client A*

- For consistency and ease of BIM model interchange, both consultants and clients agreed that BIM standards are very important. In fact, setting up BIM Standards are the first and most important thing that the project BIM manager should consider when getting started.

*“The standards should be set before any of the designers start modelling in order to have a consistent set of standards for all stakeholders.” – Consultant F*

- It was also agreed that all parties should understand their roles and responsibilities at the start of BIM coordination. This is usually part of the BIM Execution Plan set for the project by BIM Management.
- The consultants highlighted that BIM Management should be ‘supported’ by clients, rather than ‘led’ by client. The client should definitely have an understanding of the process, and if possible, the software in order to maximize BIM potential on the project.

*“The list of BIM deliverables to the client has to be managed by BIM management in order to keep the client expectations real and manageable.” – Consultant F*

*“The Client and BIM Management Company need to be on the same page with regards to the client deliverables and the time taken to achieve those deliverables.” – Consultant F*

- It was observed from the on-going project that BIM Management performs and coordinates the entire clash management process. BIM Management receives the models, sets the parameters for clash detection, runs the clash check, sorts the clashes into groups, prioritizes the groups based on severity, generates the clash management report and send the reports along with clash models to the designers/contractors for revision.
- All the project stakeholders agreed that constant interaction/team meetings are necessary between all members of the company in order to incorporate BIM into the project management workflows.

### **BIM-based Application**

- It was suggested that clients do not need to understand all the details of the software, but they should have a general understanding of what the software capabilities are. This is supported by the consultants where client understanding is needed to manage their expectations from the project, and not based on their theoretical understanding of BIM.
- Both clients and consultants recommended that the selection of BIM based applications/software has to be decided by the BIM Management company. The applications/software need to have enough specialized staff in BIM Management to deal with the deliverables.

*“Some clients can have a preferred BIM system, in that case which can be included in the procurement policy.” – Client A*

*“It is recommended that the consultants’ choice of software be taken into consideration while making a decision.” – Consultant F*

- It was observed that BIM-based applications are determined depending on the project requirements and the phases within which the applications are used. This process has to be led by BIM Management.
- Both the client and consultants agreed that BIM Management plays an important role in deciding on IT infrastructure, as the infrastructure is directly proportional to the applications being utilized. The IT manager, if available, should be the one to decide on the infrastructure.
- The experience of both the client and consultants revealed that there are numerous advantages of using BIM based applications instead of the conventional 2D method. The primary one being the ability to visualize the models and the project. Another advantage is the parametric nature of these applications.

## 7.6 Summary

This Chapter is concerned with the case studies which aimed to validate the proposed process protocol. Three case studies were conducted involving three typical high-rise building projects (residential and commercial) in the UAE. The first case study was used as a “control case” to validate the impact of the local culture on the proposed process protocol (including the use of new technology (BIM) and the collaborative delivery method). The process protocol was then updated using the findings of Case Study One to suite the local conditions. The analysis of the findings of this case study also showed that there are nine important criteria that underpinned the main process protocol.

Case Studies Two and Three were selected because of their BIM/collaboration implementation. The cases were carried out to validate the process protocol based on the nine criteria. Several semi-structured face-to-face interviews were carried out in both case studies with selected qualified staff from client committees, consultants and contractors. The outcome showed that all the nine criteria are important and need to be accommodated to strengthen the process protocol. The following Chapter will further discuss the findings of these three case studies, their effects on the process protocol before a conclusion and recommendations are made.



# **Chapter 8:**

## **Discussion**

### **8.1 Introduction**

In Chapter 7, it was explained how case study one has been deployed to investigate the main problems encountered during the construction of typical projects in the UAE. This has been carried out by interviewing the main parties involved; members of the client committee, the client representative on-site, the project management company, and the contractor. Information about the delays were collected from each partner individually and then were analysed and categorised into a number of groups based on their significance on time and cost. Nine important criteria were proposed from the findings of case study one.

Case Studies Two and Three used this criteria to further evaluate, verify and validate the process protocol. The outcomes from Case Studies Two and Three together, supported by literature, were used to validate and finalise the various components of the process protocol. This chapter also discusses in detail the findings of Case Studies Two and Three, according to the nine categories, and stresses their impact on the various components of the process protocol. The final process protocol is presented in this chapter.

### **8.2 Key Findings – Case Study One**

The analysis of the information collected during Case Study One has led to the identification of four “key elements” which construction problems can be attributed to. These are (i) client leadership, (ii) BIM and collaborative environment (IPD), (iii) planning and (iv) legal contracts. Details of these “key elements” are elaborated in the following sections.

### **8.2.1 Client Leadership**

- a. This is articulated mainly in client briefs and project specifications as well as in imposing strict quality assurance and control procedures during design and construction to ensure that the client's requirements are met at all times.
- b. It is quite evident that this role has to be exercised effectively in order to maximize the benefits to client organisations. As in any construction project which is constructed under a traditional procurement, each party (whether a consultant, contractors or subcontractors) will be mainly looking after their own interests and avoiding taking any risks which might jeopardise their contractual agreement with the client. For this reason, each individual party will be working separately of one another, which makes the task of coordinating and sharing project information extremely difficult to achieve. Therefore, clients need to take a leading role in creating a collaborative environment where project partners can share experiences and exchange project information in the interests of the project. In addition, the client needs to enforce clear quality assurance and quality control procedures to ensure that project partners deliver the best service to the client.
- c. This has clearly been demonstrated in the lack of clear and comprehensive "client briefs" and "quality control procedures" which are required to ensure that clients' requirements are met at all times during design and construction. For example, problems related to insufficient MEP design, the placement of a major electro-mechanical plant on the roof, the introduction of a plaza enclosure, etc., could have been significantly reduced, avoided or better controlled, by having strong leadership which brings partners together to effectively address the proposed changes and to produce the most cost-effective solutions which minimises reworks onsite.

### **8.2.2 BIM and Collaborative Environment (IPD)**

- a. This is implemented mainly by creating a collaborative environment during design and construction to ensure that a fully coordinated design is achieved as

well as developing integrated BIM solution for visualization, cost analysis, construction simulation, etc.

- b. The case study has clearly demonstrated that collaboration between the project partners is critical for delivering cost-effective and coordinated design. In such large projects, collaborative environments enable project partners to get together and openly share their experience and project information in the interests of the client. Most importantly, they should understand and agree to share project risks among themselves as well as sharing any benefits that come out of working together in terms of financial saving.
- c. The lack of a collaborative environment is clearly demonstrated in almost all of the identified delays. Such an environment could have played a significant role in the production of an effective initial design in line with the local culture and environment thus avoiding clashes with contractors' abilities to construct the project and meeting material specifications required by the consultants. Secondly, the collaborative environment would lead to the production of fully coordinated design amendments with minimum impact on a) existing construction and structures, b) specified equipment and building systems, c) materials delivered to site and d) site interruptions.
- d. A high level of collaboration can be facilitated by making project information accessible to all project partners as and when required in order to evaluate the impact of their design and construction solutions onto the quality of the project and its performance over its lifecycle. BIM has been proven to be an effective tool to provide a repository of project information where all graphical and non-graphical information can be stored and retrieved to satisfy the requirements of the project partners. The immediate benefit that partners will get from the implementation of BIM is a coordinated design with minimum clashes between its various building elements. However, with strong client leadership and BIM management, BIM can provide the platform within which alternative design solutions can be quickly and easily evaluated for the best interest of the client such as energy efficiency, construction simulation, initial and detail costing, return on investment, accurate quantities and lists of building elements.

- e. Although there have been a number of large changes during the construction of the project such as the introduction of the plaza and the change of space usage, there is still a significant amount of money that could have been saved if the project partners had shared a common vision towards achieving a quality project and proper coordination and collaboration environments were put in place. This can be clearly demonstrated by differentiating the cost of designing and constructing the former from those costs related to the latter. In Chapter 7, Table 7.3 shows that the total cost (including loss of income) incurred by the various changes were estimated to be 781.3 million AED. Whilst Table 7.4 shows that the estimated cost caused by ill coordination and the lack of a collaborative environment is equivalent to 568 million AED. This implies that the proposed project changes could only cost 213.3 million AED if a proper collaborative environment were in place.

The result is very much in line with the Investor Report (BIM Task Group, 2012) which proposed that there is a potential saving of approximately forty percent if BIM is used at the “tender” and “construction” stages through the coordination of contractor design information, the delivery of coordinate information to the construction team and the use of 4D (construction simulation) which offers a clear understanding to package contractors. Hence, this case study can be considered as one of the first cases to demonstrate this type of saving by using BIM/IPD associated with strong client leadership.

- f. The case study has clearly demonstrated that many problems could have been effectively eliminated just by the visualization of the 3D model. For example, if the 3D model was available for the client to visualize prior to construction, the problem related to the plaza enclosure and the canopy would have been actively addressed at the design stage, regardless of the consultant’s location, i.e. being a local or international consultant. In addition, the construction simulation of the project would have highlighted some warnings regarding the placement of the main chillers on the roof of the building for the project partners to evaluate. The sequence of construction activities would have highlighted the delays in internal furnishings due to the incompleteness of the cooling system. As this project comprised 72 floors, this problem would have been very easily spotted by the contractor.

- g. Careful study of the above problems, which occurred during the design and construction, clearly demonstrates that the combination of BIM/IPD with a high level of collaboration is becoming increasingly important for large and complex projects. This approach is clearly indispensable for such projects not only for the UAE but also around the world.

### **8.2.3 Planning**

- a. This is articulated in effective and adequate planning during design and construction to ensure that all disciplines are fully integrated and evaluated.
- b. This case study clearly shows that the project does not lack the technical expertise and skills (represented by internationally recognized firms, consultants, project management companies and contractors). What makes a difference is the leading role of the client who can bring the project stakeholders together to share objectives, set targets, plan for design and execution and evaluate and improve the project. With BIM/IPD, this process can be done effectively as information can be made readily available for partners to undertake good planning and make informative decisions.

### **8.2.4 Legal Contracts**

- a. This is mainly articulated in producing “watertight” contracts which clearly specify the role and responsibility of each partner.
- b. It is evident from Case Study One that the main hurdle to achieving a good level of collaboration and effective sharing of project information is the constrained role and responsibilities of each stakeholder as defined by their contract (as explained earlier).

## **8.3 First Alteration to the Process Protocol**

The information gathered from Case Study One was analysed and grouped according to the main events encountered during the construction stage. They were then linked to the main contributing “key elements”. This has helped to focus efforts onto the

problems of the various components of the process protocol, being the party involved (vertical axis) or the concerned phase/process of the project (the horizontal axis). Table 8.1 shows the outcome of this exercise. The table lists the “key Elements” for each problem along with its related party and the key related phases.

Table 8.1: Linking the Problem to the Process Protocol

Event Description	Key Elements	Concerned Party	Key Phases (related to)
<b>MEP Design Related Problems</b>			
1. Insufficient MEP Design	<p><b>Client leadership</b> – Preventative Measure</p> <p><b>Collaborative Environment and BIM</b> (After the decision was made to change the use of the building)</p>	<p>Project Department/ BIM Office</p> <p>Consultants, Contractors, Subcontractors</p>	<p>Phase 1 - “Prepare project brief &amp; option appraisal” Phase 3 - “Review project brief implementation” Phase 4 - “Review and finalise project brief implementation”</p> <p>Phase 2 – “Identify level of Collaboration” Phase 3 – “Prepare Bid and Establish BIM Implementation Team (BIT)” Phase 4 – “Create collaborative environment” Phase 5 – “Create collaborative environment”</p>
2. Placement of the major electro-mechanical plant on the roof of the building	<p><b>Client leadership</b> – Strict Design Review</p> <p><b>Collaborative Environment and BIM</b> - Cross Checking</p>	<p>Project Department</p> <p>Consultants, Contractors, Subcontractors</p>	<p>Phase 1 – “Prepare Quality Assurance/Control Plan” Phase 4 – “Perform Quality Control and Design Review”</p> <p>Phase 4 – “Establish BIM knowledge &amp; Preparation” “Define Integrated BIM Solution” “Create Collaborative Environment” “QC of BIM Integrated Design” Phase 5 – “Create Collaborative Environment” “Implement BIM integrated solution”</p>
3. Delay commencement of wild air and testing and commissioning	<p><b>Collaborative Environment and BIM</b> - Cross Checking</p>	<p>Consultants, Contractors, Subcontractors</p>	<p>Phase 4 – “Establish BIM knowledge &amp; Preparation” “Define Integrated BIM Solution” “Create Collaborative Environment” “QC of BIM Integrated Design” Phase 5 – “Create Collaborative Environment” “Implement BIM integrated solution”</p>

Event Description	Key Elements	Concerned Party	Key Phases (related to)
<b>Introduction of the Plaza</b>			
4. Introduction of Plaza enclosure	<b>Client leadership</b> – Strict Design Review & Control  <b>Contract</b> - Roles & Responsibility  <b>Collaborative Environment and BIM</b> - Cross Checking	Project Department  Legal Department  Consultants, Contractors, Subcontractors	Phase 4 – “Perform Quality Control and Design Review” Phase 5 – “Perform Quality Control Overview”  Phase 2 – “Prepare Contractual agreement” “Approve final contract”  Phase 4 – “Establish BIM knowledge & Preparation” “Define Integrated BIM Solution” “Create Collaborative Environment” “Review Design for Constructability & Cost” “QC of BIM Integrated Design” Phase 5 – “Create Collaborative Environment” “Implement BIM integrated solution”
5. Delay of the finalization of the canopy frit pattern and design	<b>Client leadership</b> – Strict Design Review & Control  <b>Collaborative Environment and BIM</b> - Cross Checking	Project Department  Consultants, Contractors, Subcontractors	Phase 4 – “Perform Quality Control and Design Review” Phase 5 – “Perform Quality Control Overview”  Phase 4 – “Establish BIM knowledge & Preparation” “Define Integrated BIM Solution” “Create Collaborative Environment” “Review Design for Constructability & Cost” “QC of BIM Integrated Design” Phase 5 – “Create Collaborative Environment” “Implement BIM integrated solution” “Prepare & Update Project Execution Plan”
<b>Architectural and Structural Design Related Problems</b>			
6. Value engineering and value engineering reversal	<b>Client leadership</b> – Strict Design Review & Control	Project Department	Phase 2 – “Identify level of Collaboration” Phase 3 – “Prepare cost and VE plan” Phase 4 – “Review and finalise project brief implementation”



Event Description	Key Elements	Concerned Party	Key Phases (related to)
	<b>Contract - Roles &amp; Responsibility</b>  <b>Collaborative Environment &amp; BIM – Design consistency &amp; management</b>	Legal Department  Consultants, Contractors, Subcontractors	Phase 2 – “Prepare Contractual agreement” “Approve final contract”  Phase 4 – “Create Collaborative Environment” “Review Design for Constructability & Cost” “QC of BIM Integrated Design” Phase 5 – “Create Collaborative Environment”
7. Detailed design – Design discrepancy	<b>Client leadership – Brief &amp; Project Specifications</b>  <b>Contract - Roles &amp; Responsibility</b>  <b>Collaborative Environment &amp; BIM– Design consistency &amp; management</b>	Project Department  Legal Department  Consultants, Contractors, Subcontractors	Phase 1 – “Prepare project brief & option appraisal” Phase 3 – “Review project brief implementation” Phase 4 – “Review and finalise project brief implementation” “Perform Quality Control and Design Review”  Phase 2 – “Prepare Contractual agreement” “Approve final contract”  Phase 4 – “Create Collaborative Environment” “Review Design for Constructability & Cost” “QC of BIM Integrated Design” Phase 5 – “Create Collaborative Environment”
8. Improper quality control for the structural reinforcement work	<b>Collaborative Environment &amp; BIM – Constructability</b>	Consultants, Contractors, Subcontractors	Phase 4 – “Establish BIM knowledge & Preparation” “Create Collaborative Environment” “Review Design for Constructability & Cost” “QC of BIM Integrated Design” Phase 5 – “Create Collaborative Environment”

Event Description	Key Elements	Concerned Party	Key Phases (related to)
9. Inadequate planning for the transfer structure	<b>Client leadership</b> – Process Control  <b>Planning</b>  <b>Collaborative Environment &amp; BIM</b> – Design Consistency & Management	Project Department  Contractor  Consultants, Contractors, Subcontractors	Phase 4 – “Perform Quality Control and Design Review” Phase 5 – “Perform Quality Control Overview”  Phase 5 – “Prepare & Update Project Execution Plan”  Phase 4 – “Create Collaborative Environment” “Review Design for Constructability & Cost” “QC of BIM Integrated Design”  Phase 5 – “Create Collaborative Environment” “Implement BIM integrated solution” “Prepare & Update Project Execution Plan”
10. Improper quality control for the Architectural work	<b>Client leadership</b> – Brief & Project Specifications        <b>FM Department</b> – Operation & Maintenance   <b>Collaborative Environment &amp; BIM</b> – Design Management	Project Department      Consultant  FM Department   Consultants, Contractors, Subcontractor, suppliers	Phase 1 – “Prepare project brief & option appraisal” Phase 3 – “Review project brief implementation” Phase 4 – “Review and finalise project brief implementation” “Perform Quality Control and Design Review” Phase 5 – “Perform Quality Control Overview” “Perform cost control overview”  Phase 4 – “QC of BIM Integrated Design”  Phase 1 – “Define FM requirements & Plan” Phase 4 – “Integrating FM requirement & Plan”  Phase 4 – “Create Collaborative Environment” “Define Integrated BIM Solution” “Review Design for Constructability & Cost” “Provide Product Details & Evaluation” “QC of BIM Integrated Design” Phase 5 – “Create Collaborative Environment” “Implement BIM integrated solution”

Event Description	Key Elements	Concerned Party	Key Phases (related to)
			"Prepare & Update Project Execution Plan" "Manage on site resources"
11. Waste	<b>Client leadership</b> – Brief & Project Specifications  <b>Collaborative Environment &amp; BIM</b> - Constructability	Project Department  Consultants, Contractors, Subcontractor, suppliers	Phase 1 – "Prepare project brief & option appraisal" Phase 3 – "Review project brief implementation" Phase 4 – "Review and finalise project brief implementation" "Perform Quality Control and Design Review" Phase 5 – "Perform Quality Control Overview" "Perform cost control overview"  Phase 4 – "Create Collaborative Environment" "Review Design for Constructability & Cost" "Provide Product Details & Evaluation" Phase 5 – "Create Collaborative Environment" "Prepare & Update Project Execution Plan"
<b>Problems Related to Local Authority's Requirements</b>			
12. Insufficient car parking	<b>Client leadership</b> – Preventative Measure  <b>Collaborative Environment and BIM</b> (After the decision was made to change the use of the building)  <b>Local Authority</b> – Frequent Update	Project Department  Consultants, Contractors,  Contractor	Phase 4 – "Review and finalise project brief implementation" "Perform Quality Control and Design Review" Phase 5 – "Perform Quality Control Overview"  Phase 2 – "Identify level of Collaboration" Phase 3 – "Prepare Bid and Establish BIM Implementation Team (BIT)" Phase 4 – "Create collaborative environment" Phase 5 – "Create collaborative environment"  Phase 5 – "Prepare for Local Authority Approval"

Event Description	Key Elements	Concerned Party	Key Phases (related to)
13. Reinstatement of external roadwork	<b>Client leadership</b> – Quality Control	Project Department	Phase 5 – “Perform Quality Control Overview”
	<b>Collaborative Environment and BIM</b>	Consultants, Contractor	Phase 5 – “Create Collaborative Environment”
	<b>Local Authority</b> – Frequent Update	Contractor	Phase 5 – “Prepare for Local Authority Approval”
14. Metering strategy and connection of utilities	<b>Client leadership</b> – Brief & Project Specifications	Project Department	Phase 1 - “Prepare project brief and option appraisal” “Define project definition” Phase 3 – “Review project brief implementation” Phase 4 – “Review and finalise project brief implementation” “Perform Quality Control and Design Review”
			Phase 5 – “Perform Quality Control Overview”
	<b>Local Authority</b> – Frequent Update	Consultant Contractor	Phase 4 – “Prepare for Local Authority Approval” Phase 5 – “Prepare for Local Authority Approval”
	<b>FM</b> – Operations and Maintenance	FM Department	Phase 1 – “Define FM requirements & Plan” Phase 4 – “Integrating FM requirement & Plan”
	<b>Planning</b>	Contractor	Phase 5 – “Prepare & Update Project Execution Plan”
	<b>Collaborative Environment</b> – Design and Planning	Consultants, Contractor	Phase 4 – “Create Collaborative Environment” “Review Design for Constructability & Cost” Phase 5 – “Create Collaborative Environment”

### 8.3.1 New and Amended Processes

Table 8.2 lists the new and amended processes. This came about as a result of cross-checking the findings of Case Study One with the initial process protocol presented earlier in Chapter 6, Figure 6.2. By focusing on the “key elements” which were discussed earlier, a number of processes have either been amended or newly added. This exercise has validated the applicability of the proposed process protocol to the local conditions in the UAE and the region.

Table 8.2: Amended Process Protocol from Case Study One

Phase	Amended/New Process	Comments
1	-	<input type="checkbox"/> No process was amended
2	<input type="checkbox"/> Identify level of Collaboration	<input type="checkbox"/> This process was moved from BIM Office to the Project Department
3	-	<input type="checkbox"/> No process was amended
4	<input type="checkbox"/> Create collaborative environment	<input type="checkbox"/> New process for Consultants, Contractors & Sub-Contractors
5	<input type="checkbox"/> Prepare & update project execution plan <input type="checkbox"/> Prepare for local authority approval	<input type="checkbox"/> Updated process for Contractors (adding more tasks to the process) <input type="checkbox"/> New process for Contractors to comply with

## 8.4 Key Findings – Case Study Two and Three

The aim of Case Study Two and Three was to validate the various components of the process protocol. The findings of these cases are discussed under the nine criteria as mentioned in Chapter 7. The nine criteria are as follows: client leadership, project brief, capacity/maturity, project phase decision, facility management, contracts, collaboration, BIM management and BIM-based application. The following sections discuss the key findings of Case Studies Two and Three according to the nine criteria.

#### **8.4.1 Client Leadership**

- a. Client leadership is observed and agreed by all of the interviewees as an important criteria and a key element to the successful implementation of projects. It should start at the very early phase of the project. This is in-line with the suggestions proposed by the National Improvement and Efficiency Partnership (NIEP) (2012) and the new RIBA plan of work RIBA (2013) where knowing about how a building will be used is an essential part of securing long-term value which will enhance the prospects for sustainable use of a project. The interviewees stressed that setting up a client's committee at the early stages is important as here the appropriate roles and responsibilities for all project stakeholders can be clearly defined.
- b. The client needs to have a clear picture on the overall expectations and deliverables for design and construction. It is anticipated that early involvement of clients to make clear decisions on key milestones can give advantages to the project. The findings was previously highlighted in the NIEP study (2012) which proposed that the client should lead on good design where delivering quality is about making the right connections between design decisions and their construction costs.
- c. As clearly stated in both cases, the client roles and responsibilities should not only cover the capabilities to handle and resolve design and construction issues but should also give support on BIM development and project management. As has been observed in both cases, the client committee should participate in the formulation of a BIM management plan for each project so that all the expectations can be clearly defined and hence effectively managed.
- d. Clients should encourage the setting up of a work environment based on trust within which project stakeholders can collaborate effectively. This should also include complying with standards to ensure the consistencies of information sharing among the project stakeholders at all stages of the project.
- e. Clients should lead and manage the BIM development processes across various stakeholders to ensure the development of a coordinated and

consistent BIM throughout the design and construction. It is strongly recommended that client organisations should have a specialized department that can manage and monitor collaboration and BIM implementation. As proposed by the RIBA (2012), the client should have a strong team, which includes client representatives, technical advisors appointed by the client representatives and delivery managers, to ensure the supply chain is progressing as planned. This strong team could exist in an appropriate department managed by the client. As the projects progress, clients could gain more benefits and experiences that could be used for future projects.

#### **8.4.2 Project Brief**

- a. There was a consensus among all interviewees that the project brief is important and critical for a project where the client gives early direction and articulates his goals/aims for the project. Many researchers such as Paola (2011), Othman *et al.* (2004) and Othman *et al.* (2005) have already highlighted the importance of the project brief.
- b. It is observed and agreed from the two case studies that the project brief needs to be prepared at the very early phase of the project. This is in line with what has been proposed by Constructing Excellence (2004a), Yu *et al.* (2006) and Kamara and Anumba (2001).
- c. With the present BIM, the client should derive the project brief to include also BIM strategies by considering the client's and other project stakeholder's requirements and capabilities. This finding was highlighted earlier by the BIM Industry Working Group (2011), the CabinetOffice (2011), the CabinetOffice (2012) and HM Government (2012).
- d. It was observed that for an effective project brief, the involvement of a body such as a client committee and client FM experts/advisors would ensure that all FM requirements and plans are accommodated in the project brief. This is also applied to specialized and complex projects, which might involve special requirements, specifications, targets and experts.

- e. It was evident from the interviewees that both consultants and contractors need to prepare the project brief implementation report to ensure that they understand all the project requirements and how they will be met before the tender can be awarded. The report should also include responses to the BIM-based selection criteria.

#### **8.4.3 Capacity/Maturity**

- a. In both case studies, BIM was new to both the client and project stakeholders. Identifying BIM capabilities at the very early stages of the project is very important to ensure that project requirements (project brief) can be successfully met. Many researchers such as Arayici *et al.* (2009), Suermann (2009) and Gu and London (2010) have highlighted the importance of identifying BIM capabilities at the early phases for successful implementation of BIM. Balancing between the maturity level and the expected level of deliverables, among clients and project stakeholders, is necessary to identify what can be practically achieved from BIM implementation and how benefits can be maximized.
- b. It was observed from the case studies that direct involvement of the client throughout the project has improved their understanding of BIM processes, i.e. what the expectation should be from each of the deliverables. Other project stakeholders, on the other hand, have mainly focused on developing capabilities in mastering BIM tools (Hardware and software) and have followed the procedures and standards laid out by the project management company.
- c. Continuous reviewing of BIM capabilities throughout the project by both the client and project stakeholders is important. It was observed from the case studies that both the client and other project stakeholders gained BIM experience through a number of interactive design workshops and continuous educational programs, such as training, seminars and conferences.
- d. It was also noticed that the outcome from collaboration workshops could have been significantly improved if the project stakeholders had better capabilities to manage the interface between design and construction without being



constrained by the “traditional” experience and the risk management practices.

#### **8.4.4 Project Phase Decision**

- a. At the end of every phase of the project, issues, problems, experiences gained, data collections etc. can be collected and recorded. Such collections give very useful feedback and have the potential of reducing risks and improving the performance of future projects. It was observed and agreed, both by the client and consultants, that the project feedback/review process was immensely helpful to keep track of the lessons learned. In addition, coordinated design information and FM data are both useful, if made available during the operational and maintenance stages of the project as highlighted by Sabol (2008), Azhar *et al.* (2008) and Sapp (2010).
- b. It was observed from the case studies that project information, data collection tasks and feedback should be managed by the client through a specialized BIM management office while consultants and contractors should be responsible for providing relevant data and information to collect and use over the lifecycle of the project.
- c. It was also observed from the case studies that the use of “decision gates” to monitor the phases of the project are useful to ensure that processes are successfully performed and appropriate decisions are made prior to moving to the next phase of the project. For example, project requirements need to be carefully defined, discussed and approved before the required level of collaboration and appropriate procurement path can be agreed. This is supported by previous studies by Cooper (1994) and Cooper *et al.* (2005) with the aim of reviewing the work executed in this phase, approving progress to the next phase, and planning the resourcing and execution of the next phase.

#### **8.4.5 Facility Management**

- a. Facility management (FM) is an important element for maintaining the lifecycle of the building/project. As highlighted in the project brief above, there was a

consensus that FM requirements should be considered and accommodated at the very early phase of the project. A recent study by Hungu (2013) highlighted that for efficient FM operation, all information needed to be accommodated at the early design stage of the BIM model. This should also include local authority requirements on sustainability and others. In addition, BIM requirements for FM (LoD 500) need to be identified and listed.

- b. It was highlighted, in both case studies, that decisions made on the selection of MEP systems could be the most important ones that could significantly affect the performance of the project over its lifecycle. The interviewees recommended performing lifecycle analysis during the early design stages to evaluate alternative designs and to select the most appropriate one. Recent studies by Bayer *et al.* (2010), Basbagill *et al.* (2013) and Khasreen *et al.* (2009) stressed that lifecycle analysis can be used to enable better early stage decision-making by providing feedback on the environmental impacts of BIM design choices.

#### **8.4.6 Contracts**

- a. The type of contract defines the roles and responsibilities of project stakeholders and hence determines the expected level of collaboration. Most BIM documentation and guides highlighted the importance of defining roles and responsibilities in the contract (BCA, 2013b; CURT, 2010; VA, 2010). It was observed, from both case studies, that the client and consultants agreed that the collaboration terms should be mentioned in the contract including the roles and responsibilities of each party regardless of the type of the contract selected.
- b. In case two, it was initially anticipated that a high level of collaboration could be achieved (aiming at a level 3 collaboration). However, it was found, during the execution of Case Study Two that due to local regulation and constraints, collaboration level 2 was more appropriate with multi contracts, along with a common responsibility matrix with clear BIM-based deliverables for each stage of the project.

- c. The constraints imposed by the current contractual arrangements prevented the client from adopting a full collaboration approach. This issue was overcome by reverting back to selecting the most appropriate consultants and contractors based on value-added rather than the lowest bid price which is in-line with most of the proposed procurement strategies (FIDIC, 2011; HM Treasury, 1997; IADC, 2008). This ensured that an acceptable level of collaboration among all project stakeholders could be achieved with the appropriate knowledge, capabilities and maturity.
- d. It became clear that although the legal departments of client organisations prepare the contracts, issues like BIM and other advanced technologies meant that other departments such as the “BIM Office” and project department should be involved in the framing of the contract and agreeing on the level of collaboration before the final contract can be approved.

#### **8.4.7 Collaboration**

- a. It is indicated that early involvement of all project stakeholders, especially the contractor and subcontractors, is very important. Many issues such as constructability, value engineering and material selection can be done in a flexible and effective way with no additional cost or delay. Projects have become increasingly complex and require the early involvement of all participants which allows greater pools of expertise and better understanding as proposed by AIA (2010) as one of the contractual principles for IPD.
- b. The initial aim of Case Study Two was to have a consortium comprising all the project stakeholders collaborating with each other at the very early design phase. However, it was proved that selecting the most appropriate consultants and contractors could still achieve a successful level of collaboration.
- c. On the technology note, it was observed from both case studies that the use of Bentley ProjectWise®, as a single repository for managing design documents, was very useful in providing an independent management system for the collaborative environment. Such a system can be tailored to suit the project requirements and specifications and has been widely used by many reputable

companies worldwide such as Bechtel, US Army Corps of Engineers (USACE), Dutch Engineering Firm Movares, China Water Northeastern, etc. (Bentley, 2014).

- d. During the design stage, it was observed and agreed by both consultants and contractors that high-level design reviews should be performed by the clients' experts. A report by the National Audit Office (NAO) (2004) revealed that not only is sound and creative design an essential ingredient in achieving value for money but also the need to meet the requirements of the business and all stakeholders, particularly the end users. Such collaboration on design production can avoid any surprise delay or unexpected problems.
- e. General outlines for collaboration among project stakeholders should be defined in-line with the type of chosen contract. The outline should also define the roles and responsibilities of each stakeholder along with the type of data and information that need to be shared. This outline was highlighted in NASFA *et al.* (2010), CURT (2010) and RIBA (2012).

#### **8.4.8 BIM Management**

- a. It was found at both case studies, the presences of BIM management services have proved to add a significant value to the successful implementation of BIM/IPD. It acted as independent party to evaluate the outcomes and deliverables of BIM/IPD as the projects progress. It is a critical service particularly if the project stakeholders are low in BIM maturity levels. The interviewees agreed that the role of BIM management services could vary from one project to another but for low level maturity, this service should lead to the selection of the right BIM partners and the focus on providing assistance to all parties on BIM development. The roles and responsibilities of BIM Management office was highlighted earlier in section 6.2.1 of chapter 6 and briefly discussed in BIM essential guide by BCA (2013).
- b. It was also observed from the case studies that BIM management services is essential to provide supports to the consultants and the contractor to ensure that BIM standards and processes are adhered from the early start of BIM

implementation process. Such supports including the set up of BIM standards, establishing BIM awareness, BIM knowledge and preparation. This findings were also highlighted by Singh *et al.* (2011) who emphasized in their studies that BIM management is essential on supporting technical requirements and implementation across disciplines.

- c. BIM management services, performed by an independent party, were essential also to resolve and handle the clash management process. This issue resolved clash management coordination through a series of workshops with the consultants and the contractors. BIM management services maintained an independent record of clashes and provide a frequent monitoring to the number and type of clashes. This service has provided a type of quality assurance approach to this important application.
- d. It was also noted that the BIM management services should also play an important role in deciding on the IT infrastructure selections in order to facilitate data and document exchange at all stages of the project. The successful implementation of BIM-based applications is directly related to the IT infrastructure selections. An article published by Dell and BD+C (2011) revealed that the cost of hardware versus the overall costs of the implementation will not be the deciding factor.

#### **8.4.9 BIM-Based Application**

- a. There was a general agreement among the clients, the consultants and the contractors that client organisations should understand the importance of BIM-based applications and be able to identify and approve them in collaboration with the project stakeholders. Such applications need to be developed on top of BIM (through the use of other software such as cost analysis packages, energy analysis packages, space analysis packages, etc.). Such applications can be used at various stages of the project to evaluate alternative designs, materials, construction methods, etc. It was suggested by Dell and BD+C (2011) that for anyone who implementing a BIM program, a very significant part of their responsibilities will be to develop the standards and tools needed by the entire

company to increase the efficiency and to maintain the consistency in their production work.

- b. It was also observed that BIM-based applications could depend on the project type, the requirements and the stage within which the applications are used. It is highly recommended that the client should consider and define such applications earlier in the project brief as this will have consequences on the design solutions and the resources required for developing them. BIM Management consultants should layout the rules and data exchanges for these applications to be planned and implemented by the project stakeholders as and when required. In some cases, lack of interoperability between various BIM-based applications could lead to problems as described by Azhar *et al* (2010).
- c. The experience developed by the clients and the consultants from case studies two and three revealed that there are numerous advantages of using BIM-based applications instead of the conventional 2D method. The primary ones are the ability to visualize the project at design stage to ensure that clients' feedback is accounted for and at the construction programme, it can be optimized through 4D simulation. Recent study by Barati *et al* (2013) indicated that BIM-based approach helped planners and schedulers to recognize the construction sequence, parallel activities, diminish omission of activities, hazard detection, producing of event documentation, definition of safety tasks, etc. Other advantage is the parametric values which are essential for the development of BIM-based applications.

## **8.5 General Findings from Case Studies Two and Three**

Besides the nine criteria mentioned in the sections above, there are few more observations that were made during Case Study Two and Three that could influence the final process protocol.

As mentioned earlier, there was a general agreement on the importance of the client leadership not only in making an effective and timely decisions but also in: a) understanding the level of BIM capabilities of the other stakeholders and being able to assist/allow for capacity building to enable the creation of collaborative work

environment, and b) carry out/monitor the design review processes to ensure the effectiveness and the optimisation of the design solutions. This has been demonstrated by two examples which were undertaken by the client committee as follows:

1. As part of the design review processes, the client's representative investigated and tuned the structural design, which was submitted by the design consultants, resulted in reducing the number of piles from 404 units to 168 units only, estimated saving up to 4 Million UAED (\$1.1Million);
2. On another incident, the client's representative reviewed and corrected the tower cranes selections and locations. This process saved the problem of wrong tower erection and the possibility of delay;

In Case Study Two also, the initial idea is to set up a consortium comprising the consultants and the contractors at the tender stage. However, due to local contractual constraints, this idea cannot be achieved. Therefore, the approach taken is to first appoint the design consultant by advertising the design tender then later, the appointed design consultant will select the preferred main contractor by analysing the tender submissions. Client through their legal department will negotiate and sign the contract once the final selection of the main contractor has been approved.

In addition, Case Study Two also demonstrated the demand for a well-structured and saved information for BIM to have access to. This has highlighted the need for building BIM compatible libraries of construction objects including the prices and maintenance costs.

## **8.6 Backtracking the Findings of Case Studies Two and Three to the Process Protocol**

After gathering the information from Case Studies Two and Three, detailed analyses were carried out to back track the main outcomes to the process protocol. Table 8.3 shows the outcomes of this task by listing the findings under the nine criteria, relate the findings to the concerned parties (vertical axis of the process protocol) and then link them to the appropriate phase/process (the horizontal axis of the process

protocol). Finally, the Table shows the status of each affected processes either been “updated” for the existing process or created as a “new” process. All new processes are highlighted in “BLUE”.



Table 8.3: Updated and New Processes after Case Study Two and Three

Criteria	Findings	Concerned Party	Phase (related to)	Process	Status
Client Leadership	<ul style="list-style-type: none"> <li>Have clear picture on all expectations and deliverables including BIM implementation</li> </ul>	BIM Office	1	<ul style="list-style-type: none"> <li>Define project &amp; general requirements including BIM implementation plan (Two processes merged)</li> </ul>	Updated
	<ul style="list-style-type: none"> <li>Clearly define roles and responsibilities of all project stakeholders</li> </ul>	Project Department	1	<ul style="list-style-type: none"> <li>Setup Client/project Committee</li> </ul>	New
Project Brief	<ul style="list-style-type: none"> <li>Project brief to include BIM strategy by considering the client and other project's stakeholder requirements and capabilities</li> </ul>	BIM Office	0	<ul style="list-style-type: none"> <li>Setting the procurement &amp; BIM strategy (Task moved)</li> </ul>	Updated
		BIM Office	1	<ul style="list-style-type: none"> <li>Define project &amp; general requirements including BIM implementation plan</li> </ul>	Updated
	<ul style="list-style-type: none"> <li>Project brief should also accommodate other requirements for specialized project</li> </ul>	Design Consultant	1	<ul style="list-style-type: none"> <li>Prepare brief for specialized project</li> </ul>	New
	<ul style="list-style-type: none"> <li>Both consultants and contractor need to prepare project brief implementation report to ensure that they understand all the requirements and how they are going to implement them</li> </ul>	Design Consultants And Contractors	3	<ul style="list-style-type: none"> <li>Prepare project brief implementation report</li> </ul>	New

Criteria	Findings	Concerned Party	Phase (related to)	Process	Status
	<ul style="list-style-type: none"> <li>Preparation of BIM selection criteria to ensure that they will be complied with BIM guideline</li> </ul>	BIM Consultant/PM	3	<ul style="list-style-type: none"> <li>Prepare BIM selection criteria</li> </ul>	New
Capacity/ maturity	<ul style="list-style-type: none"> <li>Project stakeholders need to gain BIM experience through a number of interactive designed workshops and continuous educational program such as training, seminars and conferences</li> </ul>	BIM Consultant/PM, Design Consultants, Contractors, Sub-contractors & Suppliers	4	<ul style="list-style-type: none"> <li>Establish BIM awareness, BIM knowledge and preparation (Task added)</li> </ul>	Updated
	<ul style="list-style-type: none"> <li>Continuous reviewing of the partners' BIM capabilities throughout the project</li> </ul>	BIM Office	2 – 5	<ul style="list-style-type: none"> <li>Discuss and Review BIM capabilities</li> </ul>	New
Contracts	<ul style="list-style-type: none"> <li>Level of collaboration need to be identified within the local conditions</li> <li>The constraints imposed by the current contractual arrangements prevented the client from adopting a full collaboration approach. Selecting the most appropriate consultants and contractors based on value-added rather than the lowest bid price</li> </ul>	Project Department	2	<ul style="list-style-type: none"> <li>Identify Level of Collaboration (Task added)</li> </ul>	Updated
		Legal Department	3	<ul style="list-style-type: none"> <li>Advertise Design Tender (Task amended)</li> </ul>	Updated
		Legal Department	3	<ul style="list-style-type: none"> <li>Negotiate/Sign Contract for Design Consultant (Task amended)</li> </ul>	Updated
		Legal Department	4	<ul style="list-style-type: none"> <li>Negotiate/Sign Contract for Main Contractor</li> </ul>	New

Criteria	Findings	Concerned Party	Phase (related to)	Process	Status
		Design Consultant	4	❑ Analyse Tender Submissions for Main Contractor's Selection	New
		Design Consultant	4	❑ Prepare Final Tender	New
Collaboration	❑ Appointment of external BIM consultant is required at an early stage to provide an independent advice on the selection criteria/maturity/assessment methods, etc.	BIM Consultant/PM,	2	❑ Appointment of BIM consultant	New
	❑ Due to local legal constraints to setting up a consortium comprising all project stakeholders, each consultants, contractors and suppliers are separately selected	Design Consultants,	3	❑ Selection of consultant	New
		Contractors, sub-contractors, and	3	❑ Selection for preferred contractor and sub-contractor	New
		Suppliers	3	❑ Selection for Suppliers	New
	❑ High level design reviews need to be performed by the client's experts with the collaboration of other project stakeholders	Project Department	4	❑ Design review	New
		Project Department	4	❑ Perform Quality Control (Task amended)	Updated

Criteria	Findings	Concerned Party	Phase (related to)	Process	Status
BIM Management	<input type="checkbox"/> Select and establish BIM partners and define their roles and responsibilities	Project Department	3	<input type="checkbox"/> <a href="#">Selecting/Establishing BIM partners</a>	New
	<input type="checkbox"/> Providing an essential support during the early startup of BIM implementation process	BIM Consultant/PM	3	<input type="checkbox"/> <a href="#">Provide guidelines, clarification &amp; assistance</a>	New
	<input type="checkbox"/> Assisting on clash management issues by coordinating all design consultants involved through a series of workshops	BIM Consultant/PM,	4	<input type="checkbox"/> <a href="#">Perform clash management</a>	New
		Design Consultants & Contractors	4	<input type="checkbox"/> <a href="#">Resolving clash management</a>	New
BIM-based Application	<input type="checkbox"/> Client organisations should understand the importance of BIM-based applications and be able to identify and approve them in collaboration with the project stakeholders	Project Department	2	<input type="checkbox"/> <a href="#">Identify value added applications</a>	New
	<input type="checkbox"/> Rules and data exchange for BIM-based applications should be defined during early design phase	BIM Consultant/PM	4	<input type="checkbox"/> <a href="#">Define rules &amp; data exchange for BIM-based applications</a>	New

## **8.7 Final Recommended Process Protocol**

The findings of the case studies presented in Sections 8.3, 8.4 and 8.5 have led to compile the final recommended process protocol. The details of the final process protocol are presented in a similar manner to Section 6.3, Chapter 6. The final process protocol along with its process descriptions matrix is shown in Appendix B.

### **8.7.1 Phase 0: Strategy Setting**

This phase aims to establish a strategy for the successful implementation of BIM/IPD for client organisations to ensure that strong client leadership is exercised throughout the design and construction of the project. This is a necessary step that will effectively produce a change program, which requires high levels of co-ordination and engagement from the various departments/units in the organisation.

#### Before the Phase:

- The Client organisation is expected to have a Strategic Planning Department/Unit, which is responsible for setting long-term plans including the type and nature of future projects along with their anticipated budgets, qualities and timescales. This unit will be responsible for developing:
  - ✓ A business case for the implementation of BIM/IPD, which should be clearly identified and understood by the client organisation.
  - ✓ Different procurement approaches to deliver high-quality projects within budget and time.
- The client organisation needs to establish a BIM Management Office to take the roles and responsibilities explained earlier in section 6.2.1 of this report.

#### During the Phase:

- A BIM strategy for the client organisation will be developed along with the types of procurement which are necessary to achieve high levels of collaboration between the project stakeholders.

- The risk and responsibilities for project stakeholders and the Level of BIM Development (Level of Development, LoD) will be defined.
- Capability assessment will be conducted to measure the readiness of both the client organisation and the potential project stakeholders for implementing BIM/IPD.
- BIM guidelines will be documented for both the client and project stakeholders.

Deliverables:

- Project Business Case Study
  - ✓ Establish the benefits, methods and estimated costs for the implementation of BIM/IPD within the client organisation.
  - ✓ Agreed quality standards and time frames.
- Project Procurement and BIM Strategy
  - ✓ Provide alternative procurement approaches with a specific focus on achieving high levels of collaboration.
  - ✓ Provide the implementation guidelines of the selected procurement approaches.
- BIM Strategy and Guidelines
  - ✓ Provide BIM standards and protocols to be used in projects.
  - ✓ Provide BIM implementation guidelines for a collaborative project environment between all stakeholders from the project's inception and throughout the facility lifecycle.
- BIM Capabilities Study
  - ✓ Provide the maturity level of the organisation.
  - ✓ Provide the level of IT readiness in-terms of software/hardware to successfully implement BIM.

### Goals:

- Establish the requirements for setting up an attractive environment within the client organisation that will satisfy the client's business requirements
- Establish all the procedures and guidelines for the implementing BIM/IPD
- Gain approval to proceed to Phase 1

### Gate Status:

- 'Hard' gate

## **8.7.2 Phase 1: Project Requirements**

This phase is the start of a set of sequential processes to successfully deliver a specific project for the client organisation based on the assumption that the organisation has a clear understanding of BIM/IPD as a result of Phase 0's outcome. The project requirements encompass a written document, the content and level of details of which vary depending on the relative complexity of the project and the expected procurement route.

Projects should start with a good briefing outline from the Strategic Planning Unit as in its annual report where projects normally are proposed for the following year. Identifying the true needs of clients in the briefing process is critical to the successful delivery of construction projects. Client satisfaction can be maximised if the client's objectives, as established in the business case for the project, are met. The form, content and extent of the Project Brief are entirely dependent on the particular characteristics of the project and the client. In case of specialise project, project brief should be prepared to cover other special requirements and specifications.

The BIM Implementation Plan for the project should be outlined at this stage. It should explain the overall vision along with implementation outlines for the project stakeholders to follow. It is highly recommended, at this stage, that the project is allocated to a project manager (champion) to be the "owner" of the project's early processes. At this stage also, client's Project Department need to setup client's/project

committee who will monitor the progress of the project. Also, the BIM Management Office should produce requirements for the production and utilisation of BIM/IPD such as modelling, visualization, information exchange and analysis, as it should assist in validating the scope and cost of the project. In addition, the quality assurance/control processes need to be identified at this stage to ensure that the project team will adopt “best practices” in the development and file exchange of building information models.

The requirements for utilising BIM for Facility Management (FM) is also essential to enable the client to leverage facility data through its lifecycle to provide safe, healthy, effective and efficient work environments. Having accurate as-built information to reduce the cost and time required for renovations; increasing customer satisfaction; and optimizing the operation and maintenance of the building systems such as reducing the energy usage.

#### Before the Phase:

- Obtain the approval to proceed; normally after the approval of the outcome of Phase 0
- Outcomes from the business case studies have been obtained and agreed
- BIM capabilities and guidelines have been outlined and are ready to be deployed

#### During the Phase:

- Develop the project brief according to the business case developed in Phase 0
- Develop additional project brief in case of specialized project
- The BIM implementation plan will be outlined
- Client's/Project committee will be setup
- The quality assurance plan will be prepared
- Facility Management (FM) requirements for the project will be defined and a plan for FM will be outlined



### Deliverables:

- Project Definition and Brief
  - ✓ Provide a comprehensive statement of the client's objectives, requirements and parameters for the project based on close consultation between the client and users in line with the local authority requirements.
  - ✓ Provide additional requirements and specifications for specialized project (if needed).
- BIM Implementation Plan and Requirements
  - ✓ Outlines the expected levels of information exchange between the project stakeholders when using BIM, particularly for analysis, at different stages of a project.
  - ✓ Outlines collaboration procedures to guide the project stakeholders in the sharing of their deliverables with other partners.
  - ✓ Provide an agreed document on BIM specifications, levels of details and processes for the development and utilisation of BIM.
  - ✓ Outlines the roles and responsibilities of the stakeholders to achieve the deliverables.
- Quality Assurance and Control Plan
  - ✓ Establish a Quality Assurance Plan for the development and utilisation of the BIM models to ensure appropriate checks on information and data accuracy.
  - ✓ Provide a checklist to ensure projects are conforming to BIM standards and use best practices in the development and exchange of building information models.
- Facility Management (FM) Requirements and Plan
  - ✓ Provide FM standard requirements to be complied during the life cycle of the project.

- ✓ Provide the principles of energy efficiency, sustainability and the need for alternative energy sources.

Goals:

- Detail project briefs including all the project requirements
- Identify potential solution(s) for the project collaboration
- A comprehensive BIM implementation plan which specifies project-specific requirements and the quality assurance plan

Gate Status:

- 'Soft' gate

### **8.7.3 Phase 2: Integrated Procurement**

This phase focuses on defining the required level of collaboration between the project stakeholders to meet the project objectives and to set up the legal documents required to achieve that level of collaboration. The required level of collaboration depends on the scale and complexity of the project, not only the complexity in its design and construction but also in managing its lifecycle (FM). The more complex the project is, the higher the required level of collaboration. The latter will also determine the mechanism and stages of the project at which collaboration should take place. The higher the level of collaboration is the earlier, it is required during the lifecycle of the project. The client at this stage should also discuss and review BIM capabilities of all project stakeholders which were identified earlier at Phase 0 to ensure that the implementation of BIM can be performed collaboratively without any problems.

A procurement strategy should determine the most appropriate contractual route that the project should take in order to facilitate the collaboration process. The “integrated procurement” phase is used to reflect the multidisciplinary framework that all project stakeholders need to work within to facilitate the defined level of collaboration. An integrated procurement route should ensure that the design, construction, operation and maintenance of the project are considered as a whole and that the delivery team

work together as an integrated project team. In addition, any contractual agreements should support risk sharing and incentives, such as financial or non-financial incentives.

Clients, more than other partners, should drive the collaboration process which should be decided and influenced as early as possible through the procurement route and contractual documents. The client organisation should exercise a strong leadership starting from this phase onward.

#### Before the Phase:

- Project requirements (project brief) should have been produced as an outcome of the previous Phase.
- An outline of the required BIM development and analysis for the project should be defined, including type and complexity of the information exchange.
- An outline of the required collaboration procedure for sharing information among the project stakeholders and the roles and responsibilities.
- Good understanding of BIM implementation.

#### During the Phase:

- Identify the client's capabilities to manage a project (mainly the department/unit responsible for the delivery of the project).
- Identify the collaboration criteria for selecting the project partners.
- Identify the general outline and the appropriate level of collaboration for the project.
- Identify the most appropriate procurement strategy, backed up with contract documents in which roles and responsibilities are clearly defined and risks/awards are clearly explained.
- Identify value-added BIM applications such as cost estimates, ROI, energy analysis, etc.

- Discuss and review BIM capabilities of all project stakeholders according to BIM implementation plan.
- Appointment of BIM consultant to assist client on BIM implementation.

#### Deliverables:

- Level of Collaboration
  - ✓ Provide a clear level of collaboration to carry out the project.
  - ✓ Provide clear criteria for collaboration partners' selection.
  - ✓ Provide the appropriate communication protocols between all project stakeholders.
  - ✓ Provide clear and well-defined management process to facilitate the collaboration process.
- Procurement Strategy
  - ✓ Provide a clear route to procure the project in support of the defined of collaboration.
  - ✓ Provide clear and well-defined type of contract documents.
- Contractual Agreement
  - ✓ Outline the roles and responsibilities of all project stakeholders.
  - ✓ Provide clear deliverables for each partner according to the level of collaboration.
- Value added BIM-based applications

#### Goals:

- Procurement strategy and type of contracts to be selected
- Finalise the contract to be tendered

#### Gate Status:

- 'Hard' gate

#### **8.7.4 Phase 3: BIM-based Tender**

This phase of the process protocol focuses on preparing the tender documents and awarding the delivery of the project by selection of consultant, preferred contractor and sub-contractor and suppliers. The previous phase provided a clear procurement path along with the most appropriate type of contracts that can achieve the project's goals. Depending on the level of the required collaboration, two procurement paths are recommended:

- 1 For large and highly complex projects (such as hospitals, airports, iconic projects, etc.) where a full collaboration level is required, it is highly recommended that the tender should be based on the establishment of professional consortiums where a number of companies bid for the project as a group with clear roles and responsibilities towards achieving the project's objectives as defined by in the project brief.

In this context, the contract type could either be a multiple party contract where all partners signed to one contract with the client organisation, or it could be similar to the design and build contract, where one party will be responsible for the delivery of the entire project.

- 2 For level 2 or 3 collaboration, the procurement path could vary based on the required level of collaboration. For example, level 2 collaboration could be based on employing a consultant to deliver a design and at the same time selecting the preferred contractor, sub-contractors and suppliers to work collaboratively to give a feedback during early design stage. In some cases, it could also be based on employing a consultant at the first instance to deliver a design at a schematic detail stage and then employ the main contractor before starting the detailed MEP design. This path will help to establish a collaborative team at the schematic design stage.

In this case, the client organisation should provide a strong leadership to ensure that all parties work towards achieving the project's objectives. Clear roles and responsibilities should be incorporated into the contract for each party.

In either case, client organisations need to have a budget, i.e. a very good cost estimate for the entire project, which the priced tender can be benchmarked against. Whether it is an early design cost estimate, based on option (1) above or a detailed design cost estimate, based on option (2), it is highly recommended that client organisations should have their own cost databases for this purpose rather than depending on general published cost information or advice from consultants.

Before the Phase:

- An agreed and approved level of collaboration
- An agreed and approved type of procurement path
- An agreed and approved type of contract in line with the selected procurement path.

During the Phase:

- Client organisation:
  - ✓ Reviewing the project brief implementation specified in Phase Two.
  - ✓ Preparation of the project budget, “client estimated cost” and VE plan.
  - ✓ Selecting/Establishing BIM partners for collaboration based on the specified criteria.
  - ✓ Discuss and review BIM capabilities of all project stakeholders according to BIM implementation plan.
  - ✓ Preparation of tender and contract documents for design consultant selection.
- Project stakeholders:
  - ✓ Provide BIM selection criteria based on the BIM implementation plan.
  - ✓ Provide BIM guidelines, clarification and assistance. This is an optional process if the BIM office did not have the capability to do it.
  - ✓ Prepare project brief implementation report.

### Deliverables:

- Reviews of project brief implementation
  - ✓ Outline a clear statement of the standards of quality required; great care is needed to ensure that standards are clear, such phrases as “the highest quality attainable within the control budget” should be avoided.
  - ✓ Outline all project requirements and clearly included in the tender documents.
- Cost and VE plan
  - ✓ Provide overall budget for the project.
  - ✓ Provide the allocation of costs over time.
  - ✓ Provide a clear guideline for VE implementation.
- Tender documents
  - ✓ Complete design tender documents to be advertised.
- BIM selection criteria
  - ✓ Outline criteria for consultants, contractors, sub-contractors and suppliers selection.
  - ✓ Outline the roles and responsibilities of all collaborated parties.
  - ✓ Provide an agreement framework for all project stakeholders to sign.
- Contract signed
  - ✓ Tender documents to be evaluated.
  - ✓ Negotiation process with the selected tenderer(s).
  - ✓ Complete contract document signed by all parties involved.

### Goals:

- Award the project to the most competitive/qualified tenderer
- Select preferred contractors, sub-contractors and supplier

- Establish a collaborative environment to implement, monitor and evaluate the project's BIM Implementation Plan

Gate Status:

- 'Hard' gate

### **8.7.5 Phase 4: Integrated Design**

This Phase focuses on the delivery of the “integrated design” through a full collaboration between the projects stakeholders. This process is facilitated by BIM. Integrated design is holistic in that it involves all partners, from design to FM, each having input into what goes into the decisions-making process that will lead to a fully constructible, functional and cost effective project, i.e. meeting all client requirements. It is holistic in that it takes every team member's point of view into consideration and decisions are made with all the information shared at one time and up front.

The best outcome for this phase can be achieved if project stakeholders are guided by trust, information sharing, collaboration and transparency where team success is equated with project success. As can be seen from the process protocol, there is a condensed level of activities required from each side, i.e. the client organisation and the project delivery team.

Yet, the project partners should establish a high level of understanding of what they can deliver through collaboration and what functionalities/analyses are required in order for BIM to meet the clients' requirements. This process has to be carried out at the early stage of this phase and should be supported later by a monitoring process (quality assurance) to ensure that all its elements are fully implemented. It is highly recommended that the QA process is performed by an independent “BIM consultant” in order to provide impartial views on both the data required to achieve the analysis and the outcome of the analysis.

In all cases, the client organisation has to provide a strong leadership to fulfill this requirement.



#### Before the Phase:

- The contract is signed by appointed design consultant
- The appointed consultants, the preferred contractors, sub-contractors and suppliers selected are ready to collaborate
- The BIM implementation plan is ready
- Project brief are clear and all requirements are put in-place

#### During the Phase:

- Client organisation:
  - ✓ Discuss and review BIM capabilities of all project stakeholders according to BIM implementation plan.
  - ✓ Monitor BIM implementation plan.
  - ✓ Perform lifecycle costing.
  - ✓ Perform cross checking on estimated project cost and design quality using BIM models.
  - ✓ Perform quality control and a design review of BIM integrated design.
  - ✓ Review and finalise the project brief implementation according to the project requirements.
  - ✓ Checking design output according to all requirements.
  - ✓ Negotiate and prepare the tender and contract documents for main contractor's selection.
  - ✓ Monitor the work progress according to the contract.
  - ✓ Integrating FM requirements and plans at the early stage of the design.
  - ✓ Approve all the milestones, VE and budget requirements.

- ✓ Discuss and approve the construction materials according to FM requirements and plans.
- ✓ Provide layout approval from the local authority.
- Project stakeholders:
  - ✓ Establish BIM awareness program and build up BIM knowledge among the BIT.
  - ✓ Implement BIM implementation plan including IT infrastructure, software and training.
  - ✓ Define rules and data exchange for BIM-based applications according to the standards.
  - ✓ Prepare integrated BIM from concept (LoD100) to detail (LoD300) stages.
  - ✓ Prepare all related documentations for the local authority approval.
  - ✓ Analyse tender submissions for main contractor selection.
  - ✓ Provide quality control (QC) procedures to streamline the content and the development of BIM.
  - ✓ Performed clash management procedures.
  - ✓ Prepare project brief implementation report.
  - ✓ Prepare final tender documents for main contractor selection.
  - ✓ Resolving clash management through a series of dedicated workshops.
  - ✓ Define integrated BIM solution and establish a collaborative environment to enable information sharing among all partners.
  - ✓ Review design for constructability and cost.
  - ✓ Collect product information from suppliers to be used during design evaluation.

### Deliverables:

- A finalised project brief implementation report
  - ✓ Integrated design will be reviewed according to the project requirements.
- Cross checking report
  - ✓ Life cycle costing will be aligned with the pre-defined cost plan.
  - ✓ Quality control of the integrated design will be aligned with the pre-defined VE plan.
- Clash free report
  - ✓ Every clash management workshops will be produced a report.
  - ✓ Other clash management issues not detected by the software will be resolved through the workshops.
- Approved construction materials
  - ✓ The proposed construction materials will be discussed and checked according to FM requirements and plan before an approval can be made.
- An established BIM awareness program to be conducted throughout the project
  - ✓ Develop a series of programs or workshops for disseminating BIM knowledge to all partners involved.
  - ✓ Assists all project stakeholders on the execution of the BIM implementation plan.
- BIM integrated design with defined rules and data exchange for BIM-based applications
- Final tender documents for selection of main contractor
- A complete and comprehensive integrated BIM to detail level (LoD300)
- Design for constructability and cost review report
- Product specifications, pricing and lifecycle costing from the suppliers

- Local Authority approval

#### Goals:

- A collaborative environment where all parties join together to achieve the objectives of the project
- An integrated BIM design model, fully coordinated and clash free is capable of fulfilling all analysis required by the client and the local authority approval

#### Gate Status:

- 'Hard' gate

### **8.7.6 Phase 5: Construction**

The construction phase of the process protocol focuses on the delivery of the project to the highest satisfaction of the client. At this phase the contractor should have an excellent understanding of the project to be delivered and should have played a significant role, as a part of the collaborative team, in making the design constructible with clear and complete specifications. In addition, specialised subcontractors should also be on board along with the suppliers who should have already contributed to the manufacturing and performance of the various building elements.

The contractors should continue to work with the project collaborative team, during this phase, to ensure that the BIM implementation plan is fully implemented. The implementation plan should clearly define all the building elements, products and systems that need to be incorporated into the BIM model to be used either for the analysis required during the construction stage or for the facility management of the building. This is a difficult task as the amount of information required to be collected from different partners might be very large. Hence, the continuous collaboration between the project stakeholders will be vital to balance between the required information and the value that it could add to the project. In addition, BIM should be updated continuously throughout the construction phase to produce the As-Built BIM, i.e. LoD500, which should also include all RFIs, change orders, and as-built/as-constructed changes that occur during construction.

The client organisation, on the other hand, should continue to provide a strong leadership during this phase to ensure that the project meets all the client requirements. This is mainly materialised by strict quality control procedures to be complied by all the project stakeholders along with a continuous implementation of cost control procedures to ensure that the project team meet their cost and time targets. The FM Department should also take part in this phase to approve the proposed BIM integrated solutions and to ensure that project stakeholders meet all the FM specifications and that all information required for managing the building after handover is taken care of.

#### Before the Phase:

- The BIM implementation plan is fully executed at the design stage
- All parties involved are equipped with the necessary BIM knowledge, training and IT infrastructure required to execute BIM development
- Integrated BIM for LoD100 to LoD300 are developed and clash free
- Full added value analysis have been carried out on the integrated design
- Integrated BIM is reviewed and verified
- Lifecycle costing is performed
- Local authority approval for the design is obtained

#### During the Phase:

- Client Organisation:
  - ✓ Discuss and review BIM capabilities of all project stakeholders according to BIM implementation plan.
  - ✓ Perform cost and quality control overview.
  - ✓ Finalise project brief implementation.
  - ✓ Approve the handover plan with the agreed requirements and outcomes.

- ✓ Perform BIM walkthrough to investigate any undetected clash and unforeseen issues.
- ✓ Monitor the construction progress according to the contract.
- ✓ Approve BIM integrated solution for FM to ensure the continuation of BIM usage into FM.
- ✓ Produce as-built LoD500.
- ✓ Perform site inspections to ensure compliance with the project requirements, regulations etc.
- Project Stakeholders:
  - ✓ Implement BIM integrated solution and maintain the collaborative environment which maintains the capabilities to share information among all parties.
  - ✓ Perform value-added analysis such as cost and energy analysis on the integrated BIM models including the actual materials used.
  - ✓ Monitor as-built BIM model and collaborate with all parties if any changes or updates are made.
  - ✓ Perform quality control (QC) and quality assurance (QA) procedures of the integrated BIM solution.
  - ✓ Provide supervision for the construction project.
  - ✓ Perform schedule simulation on the integrated BIM models to visually plan and communicate activities in the context of space and time.
  - ✓ Prepare and update the project implementation plan and extend the integrated BIM models from LoD300 to LoD400.
  - ✓ Manage on-site resources to ensure project can be performed according to the schedule.

- ✓ Coordinate site product delivery to ensure the materials supplied will arrive on-time.

#### Deliverables:

- Project handover plan
  - ✓ Provide Project Handover Checklist - reviewed, amended and updated.
  - ✓ Outline details of FM in the handover process.
  - ✓ Outline the operational and maintenance contractual arrangement.
  - ✓ Outline client engagement and training plan.
  - ✓ Outline client occupation/migration plan.
- As-Built BIM Models (LoD500)
  - ✓ Include the as-built documents that contain mark-ups, annotations, and comments about changes that have been made to the contract documents during the construction phase.
  - ✓ Include the as-built models that have been updated throughout the construction process. These changes and updates have been communicated from the contractor to the design team through the comments, annotations, and mark-ups from the As-Built Documents

#### Goals:

- Deliver the project as planned within time and cost
- Develop as-built BIM models from the project execution

#### Gate Status:

- 'Hard' gate

### **8.7.7 Phase 6: Operate (FM)**

This phase focuses on the FM stage of the project, where build information is critical to help client organisations (or their FM contractor) to formulate a long-term maintenance strategy. Through, its strong leadership and the quality control procedures that should have been exercised during the previous phases of the process protocol, client organisations should be able to ensure that all information required for the production of the as build BIM model have been captured and populated into the model. The format and depth of such information can follow the information exchange standards COBie (Construction Operations Building Information Exchange), which facilitates the transfer of digital information from the design and construction process to the facilities management databases. Thus, implementing BIM and COBie would streamline project activities with the most immediate tangible benefit being improved tracking of warranty information to avoid potentially significant costs associated with unnecessary equipment repair or replacement during the warranty period.

A critical stage after the completion of construction is the handover of the project to the client organisation. This process should be easier to manage mainly because of a) the client involvement in and knowledge of all phases of the process protocol, and b) the availability of the quality assurance documents that should have been produced during the design and construction and approved by all partners. Suppliers and specialised subcontractors, such as MEP subcontractors, in particular, have to keep updating the performance data of equipment and systems over the guarantee period.

#### Before the Phase:

- Overview of the actual costs and quality control documents are produced
- Outline handover plan is prepared and approved
- As-Build BIM models (LoD500) are developed and approved

#### During the Phase:

- Client Organisation:



- ✓ Conduct post project review to measure how the project meets its requirements.
- ✓ Monitor and handover of as-built BIM to ensure all related BIM documents and requirements are fulfilled.
- Project Stakeholders:
  - ✓ Prepare data transfer protocol to facilitate the transfer of digital information from the design and construction process to the facilities management databases for later use.
  - ✓ Prepare and check snag list of construction work for QC.
  - ✓ Suppliers update performance data in order to keep the supplied equipment performance up-to-date within the warranty period.

#### Deliverables:

- Post Project Review Report
  - ✓ Review the completed project in terms of meeting project brief and objectives.
  - ✓ Provide a basis from which lessons learnt may be applied to future projects.
  - ✓ Continuous monitoring and feedback of performance to improve future projects.
- Data Transfer Protocol
  - ✓ Prepare a database to store all data storage during design and construction phase.
  - ✓ Prepare a standard information exchange for integrating data stored with the Facility Management application for later use.

#### Goals:

- Integrating BIM with Facility Management

- Project brief is successfully implemented
- Measurement of the efficiency of the building operation and maintenance during the handover process

#### Gate Status:

- No formal gate status. The overall feedback from all phases will contribute and improve the project delivery strategy, requirements, type of procurements and the execution of the project using the proposed BIM implementation plan.

Compiling and organising all the processes and other related information presented in this section, the final recommended Process Protocol is presented in Appendix B.

## **8.8 Summary**

This chapter discussed the key findings from Case Study One, Two and Three as explained in detail in chapter 7. The aim of the case studies was to validate the various components of the proposed process protocol. First, the key findings from case study one were cross-checked with the initial process protocol. This exercise has validated the applicability of the proposed process protocol to the local conditions in the UAE and the region.

Secondly, nine criteria were derived from Case Study One and were used as a base to drive the semi-structured interviews for Case Studies Two and Three. The findings of these case studies were reported under the nine criteria. In addition, a detailed analysis was carried out to back track the main findings to the process protocol. Finally, a recommended process protocol was presented with various improvements of relevant phases and processes backed with the literature and practical experiences.

# **Chapter 9:**

## **Summary and Conclusions**

### **9.1 Introduction**

The research in the field of design and construction has been mainly focused on ways to improve sector since the early 1980's. A series of initiatives have been proposed such as the introduction of Computer Integrated Environments (CIE) in the early 1990's and further Building Information Modelling (BIM) in the late 2000's, it is widely accepted that these sorts of innovative systems can help to reduce the fragmentation of the industry and improve collaboration between project stakeholders. For this type of technology to be implemented successfully, appropriate process-based delivery approaches, such as Integrated Project delivery (IPD), are essential.

This study produced a process-based map (process protocol) to assist client organisations to better understand BIM and its delivery process using IPD and how clients can lead construction projects by accommodating better and more effective processes. This chapter provides an overall summary of the work that was carried out to achieve the objectives of this study, provides a summary of the key findings, outlines its contributions to existing knowledge and finally lists recommendations for future research.

### **9.2 Summary**

#### **9.2.1 Background summary**

Since the publication of the Egan's Report, almost two decades ago where a number of improvement targets were set for the industry to achieve, the industry is still falling short of achieving them. The report proposed a radical transformation of the UK

construction sector, identifying five key drivers of change: committed leadership, a focus on the customer, integrated processes and teams, a quality driven agenda, and a commitment to people. Constructing Excellence, in 2009, undertook a comprehensive review ten years after the Egan's report to determine the level of its impact on industry and to define the improvement agenda for the forthcoming decade. After ten years, it is found that the change in the performance of the industry was evident but still fell short of meeting the targets set by Sir Egan. The report entitled "*Never Waste A Good Crisis*" has been published based on the input of over a thousand industry professionals who completed online questionnaires and in depth interviews with key industry figures and key performance indicators from over 500 demonstration projects (Wolstenholme *et al.*, 2009). The main blockers were found to be business models based on short-term cycles, a fragmented industry, poor integration in the supply chain and a lack of strategic commitment at senior management and government level.

Greater efficiency, which could achieve significant savings – up to 30 percent - have been argued (Egan, 1998; Latham, 1994). Wasted efforts throughout the lifecycle of a building are mainly related to project stakeholders not having access to information that others have created (Hecht, 2008), i.e. working in a complex supply chain, where data used further down the supply chain has to be re-entered or recreated by other suppliers, largely because the software used by each party is not inter-operable. "The Investors Report" (BIM Task Group, 2012) reported that the construction industry captures and retains little data about the assets it delivers and operates. What data the sector does capture is rarely sufficiently analysed to allow performance on the existing project, or delivery of the next, to be improved. The National Institute of Standards and Technology (NIST) looked at this problem in the US in 2004 and estimated the total cost of inadequate interoperability at \$15.8 billion a year, the equivalent of 2.84 percent of the annual value of construction. Of these costs, two-thirds are borne by owners and operators, which incur most of these costs during on-going facility operations and maintenance (O&M) (Gallagher *et al.*, 2004).

However, there is a general understanding, among industry professionals, of the impact that project information can have if it is made readily available during the design and construction stages. Although, over the past decades, advances in

Information Technology (IT) have introduced improvement in managing information and improved the ability of organisations to restore, retrieve and reuse information, a study conducted by Construct IT highlighted that implementing technology alone will not bring satisfactory benefits without considering two key elements, i.e. people and process. The latter can give an organisation the capability to positively absorb technology into its work practices and therefore have the ability to maximise the benefits from their IT investment.

Recently, BIM has been introduced to provide a model-based mechanism to manage all project related information in a single shared repository. Using BIM, project stakeholders will have the potential of coming closer in being an accurate and multi-disciplinary collaboration. It provides a major step-change in the ability of design and construction teams to structure and exchange information around shared, computer-based models of a building project which bring great benefits, including better design coordination, reductions in design costs and improved communications throughout the design and construction process.

The successful deployment of BIM requires the traditional design and construction processes to be changed to suit the workflows associated with BIM. One of the most effective ways to deal with change is to introduce a collaborative work environment, where risks and rewards of using BIM are shared among the project stakeholders.

The key to the successful implementation of a collaborative environment such as IPD is assembling a project team that is committed to collaborative processes and is capable of working together effectively. According to the American Institute of Architects (AIA, 2007a), the main enablers for IPD are the identification of roles of partners, pre-qualification (maturity of partners), development of common goals and objectives and most importantly the development of project agreement(s) to define the roles and accountability of the participants. In addition, the National Improvement and Efficiency Partnership (NIEP) has laid down six principles that clients need to lead on. These are: (1) taking the whole-life value, (2) using framework agreements, (3) innovation in supplier relationships, (4) leading on good design, (5) commitment to sustainable development and (6) considering building management at an early stage. Such principles will make clients recognise the range of stakeholders' skills and capabilities to work collaboratively.

Although IPD seeks to break down the traditional contracting barriers, with separated silos and responsibility, by having all major participants focus on achieving shared goals, the success of IPD relies on full collaboration between the client, consultant, contractors, subcontractors and suppliers starting at the early design stages and continuing until the project handover. This requires increasing effort from designers and contractors from early design stages, aiming to reduce documentation time and improve cost control and budget management. The most important catalyst in achieving this aim is sharing risks and rewards. As IPD is generally a new concept, there is no clear or standard business model that should drive IPD contracts. Also, there is no standard definition for sharing risks and rewards. It is all to be led by clients.

This, yet again, highlights the critical role of the clients in this process. Client organisations can play a leading role in establishing trust between the project stakeholders as being the ultimate owner and beneficiary. Achieving the above is challenging and highly dependent on the maturity of project stakeholders and, most importantly, on the maturity of client organisations to create effective contractual arrangements based on trust and risk/reward sharing. A strong client leadership is necessary to ensure effective actions are taken to fully realise the potential of IPD's capability to improve the performance and quality of projects and to reduce completion cost and time.

BIM can facilitate collaboration by making project information available for partners to make informative decisions at all times. From BIM, drawings, bills of quantities, construction schedules, visualisations, fabrication instructions, overall costs etc. could be created and updated. Therefore, a whole set of tasks traditionally handled independently by architects, engineers, construction companies, and even clients such as drawing management, costing and scheduling and construction management in all its forms suddenly become interrelated with data management tasks. Hence, effective management of this task can bring significant advantages to projects but it must be supported by appropriate work practices.

The key to successful IPD is assembling a team that is committed to collaborative processes and is capable of working together effectively. Client organisations can influence collaboration early in projects through procurement and the contracting

process. Effective management of this task can bring significant advantages to projects but it must be supported by appropriate work practices. To do that, process-based maps are required to effectively present the relationship between the different types of information so that it could provide client organisations with guidelines to effectively exercise their leadership to bring about changes and to effectively implement BIM in their organisations. This is particularly important for IPD where each phase of the design and construction might require different processes to be developed which prove to be beneficial in terms of transparency and communications as well as mechanisms for managing project data and forming the basis for continuous improvement.

This research is concerned with two main challenges:

- a) BIM and its delivery process using IPD, particularly in the UAE
- b) How client organisations can accommodate better and more effective processes in order to maximise the benefits achieved from BIM implementation.

The latter challenge is critical to transferring client organisations from the traditional delivery of projects into BIM/IPD based ones. The primary aim of this research is to develop a process roadmap for the successful implementation of IPD in client organisations using BIM as the main vehicle to control and manage the integration of design and construction. The research has been focused on the identification of high level processes and their interrelationship which could provide guidance to client organisations on how to implement and manage IPD effectively. Also, the research sought to make the process road map relevant to the UAE market by investigating the impact of the UAE's local culture and legal procurement framework on the implementation of BIM/IPD.

### **9.2.2 Summary of Research Approach and Outcome**

A new business process approach is required, as a tool, to bring changes to client organisations, i.e. allowing them to integrate their business processes with technology innovations to improve their performance. To do that, a process map needs to be

developed that could depict the roles, activities and interactions of all concerned participants. In a process map, a project can be divided into discrete phases each of which has its purpose, process and scope of work. Based on the University of Salford's Generic Design and Construction Process Protocol, this research developed and validated a process protocol that can be used as a guide to help client organisations to effectively adopt BIM/IPD.

From an extensive literature review, an initial process protocol was proposed with the following principles: (1) it takes a whole project view to cover the whole 'life' of the project, (2) it adopts the "stage-gate" approach where each process at every phase will be reviewed and validated before the next phase can proceed, (3) it recognises the interdependency of activities throughout the duration of a project, (4) it involves all the stakeholders at each activity of a phase, (5) it encourages the establishment of multi-functioning teams in the early stages, (6) it has the ability to give feedback from each phase.

The proposed process protocol is capable of representing all diverse project stakeholders (from setting up an implementation strategy to the development of BIM for the project's facility management) along with their related processes for each of its seven phases. These seven phases are summarised as follows:

1. Phase 0: Strategy Setting – establishes a strategy for the successful implementation of BIM/IPD to ensure that a strong client leadership is exercised throughout the design and construction of projects.
2. Phase 1: Project Requirements – is the start of a set of sequential processes to successfully deliver a specific project for the client organisation.
3. Phase 2: Integrated Procurement – defines the required level of collaboration between the project stakeholders to meet the project objectives and to set up the legal documents required to achieve that level of collaboration.
4. Phase 3: BIM-based tender – prepares tender documents and award the delivery of the project.
5. Phase 4: Integrated Design – focuses on the delivery of the "integrated design"



through a full collaboration between the projects stakeholders.

6. Phase 5: Construction – focuses on the delivery of the project to the highest satisfaction levels with contractors having an excellent understanding of the project to be delivered.
7. Phase 6: Operate (FM) – focuses on the facility management stage of the project, with BIM facilitating a long-term maintenance strategy.

The study then validated the proposed process protocol through three case studies of three typical multi-storey buildings in the UAE. Semi-structured interviews were conducted with the client representatives, consultants, contractors and project managers. Case Study One was used as a “control case” to investigate the impact of the UAE’s local conditions on the process protocol. This case study helped to focus the efforts to backtrack the construction problems to the various components of the process protocol. A number of processes have either been amended or newly added to improve the process protocol. This exercise has validated the applicability of the proposed process protocol to the local conditions in the UAE and the region.

In addition, the analysis of the results of case study one showed that there are nine important criteria that underpin the main process protocol, the summary of which are:

1. Client leadership – clients’ roles and responsibilities, where and when client Leadership should be performed and the appropriate deliverables from client Leadership processes.
2. Project Brief – understanding of the project brief, and its appropriate phase(s) and the stakeholders involved.
3. Capacity/Maturity – understanding and appreciating the capacity of project stakeholders to deploy BIM/IPD.
4. Project Phase Decision – feedback from the project stakeholders at the end of each phase.
5. Facility Management – FM early involvement in BIM/IPD, FM requirements and BIM’s role in the operation and maintenance phase.

6. Contracts – conventional contracts and the deployment of BIM/IPD and roles and responsibilities of project stakeholders.
7. Collaboration – the initiation of the collaboration process, BIM development process and early involvement of all project stakeholders.
8. BIM Management – the initiation and role of the BIM office, and BIM management processes and phases.
9. BIM-based Application – selection of the appropriate BIM-based applications and training for their development

Case Studies Two and Three aims to validate the various components of the process protocol. Both cases have highlighted the importance of client leadership. The limitation of the client's ability to contractually bring stakeholders to work together in a collaborative environment meant that the "traditional" contracts could not be avoided (design, tender and build). Due to this fact, the concept of preferred "contractors/subcontractors/suppliers" was adopted to allow early involvement of the contractors and suppliers into the design process. This approach will enable construction feedback to be captured and fed-back to the various stages of the design process.

The findings of Case Study Two and Three were backtracked to the process protocol, i.e. backtracked to the concerned parties and then linked to the appropriate phase/process. The affected processes were highlighted either as an "update" or "new". The final recommended process protocols showing all of the seven phases are shown in Chapter 8 where all existing, updated and new actions before the phase, during the phase, deliverables, goals and gate status at the end of each phase are explained.

### **9.3 Key findings**

This section summarises the key findings of this study:

- ✓ It was found that when problems/issues are raised on construction sites, whether they are design related or otherwise, they are left to the project consultant and

contractor to solve. The direct role of the client was minimal under these circumstances, which was due to lengthy approvals processes and consequently led to large delays.

- ✓ There is a lack of a collaborative environment between the various project stakeholders which is considered to be the main cause for the identified delays in the case studies. Such collaborative environments are essential to optimizing the design processes, evaluating design alternatives, producing coordinated designs (class free designs), etc. Moreover, BIM has been proven to be an effective tool to support collaborative environments but can only be successful with strong client leadership.
- ✓ It was clearly demonstrated in Case Study One that there is a potential of a 40 percent saving in the estimated cost if BIM and collaborative environments are adopted throughout design and construction. This could be achieved through a strong coordination of the design information, the delivery of the coordinated information to the construction team, the use of 4D (construction simulation), which offers a clear understanding to contractors' work packages and detailed advanced planning. This finding confirms the content of the "Investment Report" (2011), where it is claimed that up to 40 percent can be saved if BIM is implemented at the design and construction stage.
- ✓ Construction projects in the UAE suffer from a lack of advanced planning, particularly when problems arise on construction sites. Minimal co-ordination between the concerned partners were witnessed which had led to major re-works, the adoption of costly solutions, stoppage of construction activities and hence creating large delays and lengthening approval processes.
- ✓ Local contracts and legal frameworks are found to be the main obstacle to achieving high levels of collaboration. Local contracts are based on traditional approach (design, tender and build), which enforce the separation of the project stakeholders by clearly defining their roles, responsibilities and deliverables. Under these circumstances, no partner will be willing to move out of their legal obligations in order to provide a better service even if it is for the interest of the project/client.

- ✓ Clients can take the driving seat to introduce change. This is clearly shown in Case Studies Two and Three where the client has set up a client committee to continuously review and monitor the project's progress. Issues raised can be identified, discussed and resolved as early as possible with the consensus of the client and other project stakeholders, hence speeding up the decision-making process and avoiding lengthy delays.
- ✓ It was found that selecting the most appropriate consultants and adopting the "preferred contractor" approach could still achieve a successful level of collaboration although the ideal way is to have a consortium comprising all the project stakeholders collaborating with each other at the early design phase.
- ✓ It was found that Legal/Contract Departments in client organisations cannot by themselves create and approve new types of contracts or legal frameworks to encourage collaboration. Technical know-how is required to define the outcomes of the required collaboration levels, which needs to be added to legal contracts. This knowledge comes from the specially created BIM Office and Project Department. The required level of collaboration should also be identified and agreed before final a contract can be approved.
- ✓ To achieve a high level of collaboration, it was found that clients should create a work environment that is based on trust and shared risk and reward. Local culture and contractual frameworks were found to be a major hurdle in achieving this aim.
- ✓ This study has not only confirmed the importance of the preparation of the project brief at the very early phases of the project, but has also highlighted the need for monitoring its implementation by all stakeholders across the design and construction stages. The involvement of the client committee and the client's FM experts has ensured that the proposed client's requirements and plans are accommodated in the project brief including the selection of the materials, specifications, sustainability requirements by the local authority, etc.
- ✓ With the presence of BIM, the project brief should include a BIM strategy by considering the client and other project stakeholders' requirements and capabilities. The BIM strategy should include requirements such as the

development of a BIM implementation plan, the selection criteria for consultants and contractors, the implementation of BIM standards, etc.

- ✓ It was found that the use of Bentley ProjectWise®, as a single repository for storing and managing design documents, was very useful in providing an “intelligent” management system for the collaborative environment. Such a system that can be tailored to suit project specific requirements by providing different level of accessibility authorization to documents, better version control and the implementation of standards such as BS1192.
- ✓ Identifying BIM capabilities at very early stage of the project is very important to ensuring that projects requirements (project brief) can be successfully met. If BIM capabilities and maturity levels are low, project stakeholders need to develop BIM capabilities through interactive design workshops and continuous educational programs such as training, seminars and conferences.
- ✓ It was found that client leadership with a good level of understanding of BIM capabilities could bring significant advantages (saving) to the project. For example, by activating a good level of collaboration, Case Study Two demonstrated that there could be more than \$9Million of savings both in the initial and operational cost of the project by a few structures and MEP modifications. This was facilitated by strong client involvement.
- ✓ BIM management services were found to add a significant value to the successful implementation of BIM/IPD. Its presence had created an independent role to evaluate the outcomes and deliverables of BIM/IPD as the project progressed. This was found to be critical to the quality assurance of BIM deliverables produced by project stakeholders, e.g. managing and controlling clash detection processes and leading on BIM based applications such as costing and energy analysis. The role of the BIM management services can also accommodate training and monitoring the progress of the project stakeholders if their level of BIM/IPD maturity is low.
- ✓ The automatic clash management process was found to be very useful to produce a coordinated design. Also, it was found that visual inspection of the 3D model should be carried out by the BIM management services, as an independent check, to detect other types of “clashes” which cannot be found

automatically by the BIM software, e.g. beams with high depth that create an interference with the clear heights.

- ✓ Clients, through a specialized BIM management office, should manage data collection and feedback at every phase of the project. Such collections give very useful information, which had the potential for reducing risks and improving the performance of future projects.
- ✓ Selection of MEP systems is crucial and could be the most important ones that significantly affect the performance of the project over its lifecycle. Lifecycle analysis is recommended to be performed during the early design stage to evaluate alternative designs and to select the most appropriate ones.

## **9.4 Main Conclusions**

1. There is a general agreement among all construction professionals of the importance of BIM to save costs and improve quality. However, research is still focused on the technology side of the implementation of BIM (type of data, interoperability and data exchange, standards, etc.) with little on the processes that underpin BIM deployment, roles and responsibilities, contractual and legal frameworks, etc.
2. Although the benefits of collaboration between project stakeholders are widely accepted in academia and the industry, there is little research in this field, particularly in support of BIM deployment. Collaboration is “expected” to take place between project stakeholders to improve the quality of the design and construction projects where in fact there is very little done, if any, during projects which follow traditional types of contracts, i.e. design, bid and build.
3. IPD is still a new concept, which is very much recommended to achieve better and higher quality projects. The AIA is still leading, on this front, with their publications on collaboration concepts, framework templates, classification levels of BIM development (level of development, LoDs) and roles and responsibilities of stakeholders to the BIM development process.
4. There seems to be a lack of extensive knowledge/literature on what and how to exchange project information in support of BIM-based applications. Although, the

literature covers standards to facilitate information exchanges between stakeholders, there is no extensive search with the aim to identify the type of required applications to meet clients' requirements, who should identify and support them, and what information is required for each application.

5. The level of stakeholders' maturity can have a significant impact on achieving the required benefit. The higher the maturity, the better and more significant the benefits are to the project. Although PAS1192–Part 2:2013 has mentioned the importance of the partners' selection, there are no clear criteria to be used by client organisations to guide them through the selection process.
6. Contracts and legal framework seem to be the main hurdle to creating a healthy collaborative environment. Contracts normally define the roles and responsibilities and deliverables of each party. This will make timely and relevant exchanges of information between them risky and difficult. Also, without incentives, which are clearly stated in the contract, the possibility of achieving full benefits from collaboration is very limited.
7. Client leadership is the main driver for change and achievement of high quality products at the lowest possible cost. Without strong client leadership, the design and construction process will be weakly integrated and there will be no clear monitoring, control and decision-making process which will eventually lead to project delays and cost overrun. In addition, clients are the only party that can bring all project stakeholders to work together with a “binding” contract.
8. Client organisations with large number of construction projects, need to accommodate BIM/IPD in the work practice if they want to maximize the benefits of BIM implementation. Due to the complexity of this process in terms of what types of processes are required and who should be allocated to them within the organisation, there is a need for a structure process-based road map that can provide managers with guidelines to help them make a full assessment on the requirements of change and how to carry it out.
9. The proposed process protocol is found to be the easiest tool, among others, to communicate the various roles and responsibilities to project stakeholders. The process protocol makes it easier to relate project phases and processes to their concerned parties. Also, the differentiation between the roles and responsibilities

of clients' internal departments and external parties was clear and easy to understand. This high-level presentation can be easily adopted/amended to suite certain conditions as and when required.

10. The lack of awareness on the importance of advanced technologies, such as BIM, and what it can deliver for clients/projects, by all parties including clients are one of the major contributors to the delays and waste that the industry is currently facing. Clients' roles to lead in this process (awareness) is essential, as the benefits from the implementation will go back to the project.
11. Although BIM and its applications can be developed/adopted by consultants/contractors, there is a need for an independent party to ensure that the procedures are implemented for the interest of client organisations, i.e. ensuring BIM implementation quality assurance. Working on behalf of the client, independent checks, monitoring and controlling shall be carried out to provide information on the quality of the generated information/applications, such as clash detection reports, energy analysis, cost analysis, etc.
12. Constructing the brief at the early stages of the design process and continue to update and verify its implementation is critical for achieving successful projects. Projects briefs should include the development of BIM, its expected deliverables at the various stages of the design and construction stage, and the BIM-based applications that need to be carried out to achieve the projects objectives and how the project information should meet FM requirements. The implementation of the brief should also be monitored throughout the design and construction process.
13. At large, client organisations should have a new unit created to setup BIM strategies for the organisation, create policies and BIM implementation plans, assess the internal capabilities to carry out BIM and to monitor BIM deployment throughout the organisation. A BIM office could be created in line with the Project Management Office concept.
14. To maximize the benefits to client originations, project stakeholders need to have a clear picture of all expected BIM/IPD deliverables. Any misunderstanding in the type of targets that need to be achieved and who needs to achieve them will lead to confusion and the development of incomplete BIM, i.e. BIM that has no



adequate information to meet the targets. This could lead to a negative impact on the project, BIM implementation and the collaboration concept, at large.

## **9.5 Contributions to Knowledge**

This study has contributed to both the research community and industry by developing its innovative process protocol.

### *Contributions to Research*

1. This study has stressed the importance of clients' roles in leading the implementation of BIM/IPD. The process-based approach of the study has added a new dimension to research where the aim was to maximise the benefits to clients of effective management of the development and implementation of BIM/IPD.
2. The developed process protocol focused on embedding the BIM/IPD processes into the structure of client organisations by identifying the concerned departments that need to be involved in the deployment of BIM/IPD along with defining the main processes that need to be performed by each department. In addition, the relation between internal departments and external parties are also reflected in the process protocol. These relationships lay down the foundation for a deeper understanding of the role of client originations in leading change.
3. This study has initiated the concept of a BIM office within client organisations to be responsible for the creation and implementation of BIM strategies and standards. This contribution is significant as it brings, for the first time (to the best knowledge of the researcher), the idea of a centralized regulatory body for BIM/IPD within client organisations.
4. Finally, this study has proven, through Case Study One, that the claim made by the "investor report" of potential savings of up to 40 percent can be achieved if BIM is implemented throughout the design and construction. This finding is the first proof (to the best knowledge of the researcher) to show that this level of saving can be achieved.

### *Contributions to the Industry*

1. The developed process protocol provides managers in client originations with a process-based tool to assist them to take the right steps towards transforming their organisations into BIM/IPD based ones. Through the process protocol, organisations can develop a better understanding of the steps required for change, identify processes that need to be performed by the concerned departments and to have the ability to estimate the level of resources required for the transformation process.
2. By identifying the processes required by the project stakeholders at various stages of project development; roles, responsibilities and deliverables can be identified with a good level of certainty. This information can be used to formulate appropriate clauses in contracts/legal frameworks that can help with achieving a better level of collaboration.
3. On the deployment of the process protocol, client organisations can make better and timely decisions with regards to the major steps within the project lifecycle, i.e. the ability to make informative decision on moving from one phase to another, major design reviews, the use of BIM in support of client requirements, the selection of appropriate consultants/contractors/suppliers, quality assurance, etc.

### *Contributions to Policy Makers*

1. The process protocol can provide policy makers with a strategic view of the overall requirements to successfully implement BIM/IPD across the industry in the UAE. By having a good understanding of detailed requirements at operational level, better and more effective strategic objectives can be formulated.
2. Client leadership as a strong catalyst for change should be at the core of any high level policy to improve the performance of the industry. There should be clear mechanisms to help client organization to build their capabilities in order to maximize the benefits to industry, including the establishments of BIM Management Offices.
3. Legal contracts are the major hurdle to achieving effective collaboration between stakeholders. New policies should emphasize the need for new types of contracts

to facilitate the creation of collaborative environments based on shared risks and rewards.

## **9.5 Recommendations for Future Work**

This research has succeeded in achieving its aims and objectives towards developing a process roadmap for the successful implementation of Integrated IPD at client organisations using BIM as the main vehicle to control and manage the integration process. However, due to time limitation and the scope of the research, some areas of extended work which are recommended to be further investigated and expanded are as follows:

1. The process protocol presents only high-level processes for each phase of the project. These high-level processes need to be further decomposed to show the low-level detail processes that need to be performed. In addition, implementation guidelines need to be developed to provide managers, in client organisations, with practical information on how the process protocol can be implemented in their organisations and how to “unfold it” to their external partners.
2. The process protocol has only been validated at the design stage. Other phases including construction and facility management need to be examined with the view of further validation of the process protocol. It is strongly recommended that this process protocol needs be further investigated when the case studies have reached their facility management phases.
3. This research has stressed that relationships between the maturity of partners and the level of benefits that client organisations could achieve from BIM/IPD implementation is critical. This relationship is not yet investigated or reported in the literature. It is highly recommended that future research should look into establishing a matrix that links the level of maturity with the BIM/IPD benefits.
4. Contracts and legal frameworks have been reported as the main blocker to achieving collaboration. Without “new contracts” to encourage collaboration, the industry will continue to struggle to fully benefit from BIM/IPD. Hence, it is highly recommended that future research should focus on developing and

testing multi-party types of contracts with clear collaborative roles and responsibilities along with risk sharing and rewards.

5. This research has initiated the creation of a BIM Office to have a similar role to the well-established principles of the Project Management Office. Further research is required to consolidate the tasks of such an office, its authority and reporting mechanism within client organisations. This will be particularly important to Phase 0 of the process protocol where BIM strategy setting, implementation guidelines and assessment of BIM capabilities will be carried out.

# BIBLIOGRAPHY

- 663studygroup. (2006). Chapter 8 Collecting Research Data with Questionnaires and Interviews. <http://663studygroup.pbworks.com/w/page/1050551/FrontPage>, Accessed: Nov. 2013
- ACI-NA, ACC, and AGC. (2012). *Airport Owners' Guide to Project Delivery Systems* (2 ed.)
- AGC. (2005). *The Contractors Guide to BIM* (1 ed.): The Associated General Contractors of America (AGC). Retrieved from: <http://iweb.agc.org/iweb/Purchase/ProductDetail.aspx>
- AIA. (2007a). *Integrated Project Delivery (IPD): A Guide*: The American Institute of Architectures
- AIA. (2007b). *Integrated Project Delivery: A Working Definition* (2 ed.).
- AIA. (2008). Document E202–2008 Building Information Modeling Protocol Exhibit *American Institute of Architects*.
- Aitchison, J. (1998). *Access to books and journal articles by post-graduate students on a course-work Masters' programme in Information Studies at the University of Natal*. (MIS Thesis), University of Natal.
- Alshawi, M. (2007). *Rethinking IT in construction and engineering: Organisational readiness*: Psychology Press 0203961935
- Alshawi, M., and Ingirige, B. (2002). Web-based project management: A report on web-enabled project management. *School of Construction and Property Management, University of Salford, UK*.
- Alvesson, M. (2003). Beyond neopositivists, romantics, and localists: A reflexive approach to interviews in organizational research. *Academy of management review*, 28(1), 13-33.
- Aouad, G., Hinks, J., Cooper, R., Sheat, D., Kagioglou, M., and Sexton, M. (1998). An IT Map for a generic design and construction process protocol. *Journal of Construction Procurement*.
- Arayici, Y., and Alshawi, M. (2008). A model for success. *The PPP Journal*(61).
- Ashcraft, H. W. (2008). Building information modeling: a framework for collaboration. *Construction Law*, 28, 5.
- Ashcraft, H. W. (2012). *The IPD Framework*.
- Atkin, B., and Maunsell, C. (1990). *Information management of construction projects*: TW Crow Associates 0731684206
- Autodesk. (2008). Improving Building Industry Results through Integrated Project Delivery and Building Information Modeling: Autodesk Whitepaper: Available at [http://images.autodesk.com/adsk/files/bim\\_and\\_ipd\\_whitepaper.pdf](http://images.autodesk.com/adsk/files/bim_and_ipd_whitepaper.pdf).

- Azhar, S., Khalfan, M., and Maqsood, T. (2012). Building information modelling (BIM): now and beyond. *Australasian Journal of Construction Economics and Building*, 12(4), 15-28.
- Azhar, S., Nadeem, A., Mok, J. Y., and Leung, B. H. (2008). *Building Information Modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects*. Paper presented at the Proc., First International Conference on Construction in Developing Countries, Karachi, Pakistan
- Aziz, Z. (2011). Integrated Design and Delivery Systems *Lecture Notes*: Orbee Learning Package.
- Barrett, P. (2008). A global agenda for revaluing construction: the client's role. In P. Brandon & S.-L. Lu (Eds.), *Clients driving innovation* (pp. 3-15). UK: Wiley-Blackwell.
- BCA. (2013). BIM Essential Guide - for BIM Adoption in an Organization: Building and Construction Authority.
- Benbasat, I., Goldstein, D. K., and Mead, M. (1987). The case research strategy in studies of information systems. *MIS quarterly*, 11(3).
- BIM Industry Working Group. (2011). A Report for the Government Construction Client Group Building Information Modelling (BIM) Working Party Strategy Paper: Cabinet Office. Retrieved from <http://www.bimtaskgroup.org/wp-content/uploads/2012/03/BIS-BIM-strategy-Report.pdf>.
- BIM Task Group. (2012). The Investors Report: British Standard Institution Group UK, Retrieved from: <http://www.bimtaskgroup.org/wp-content/uploads/2012/03/InvestorsReport-BIM.pdf>.
- Björk, B.-C. (2002). A formalised model of the information and materials handling activities in the construction process. *Construction Innovation: Information, Process, Management*, 2(3), 133-149.
- Blaxter, L., Hughes, C., and Tight, M. (2010). *How to research*: McGraw-Hill International 033523867X
- Block, E. (1986). The comprehension strategies of second language readers. *Tesol Quarterly*, 20(3), 463-494.
- Bourn, J. (2001). Modernising construction. *UK: National Audit Office*.
- Boyd, D., and Chinyio, E. (2008). *Understanding the construction client*: John Wiley & Sons 0470759534
- British Columbia. (1996). Guide S47 - Process Modelling Guidelines <http://www.for.gov.bc.ca/his/datadmin/s47.pdf>
- Brotherton, B. (2008). *Researching hospitality and tourism: a student guide*: Sage 1446203700
- BSI. (2010). Constructing the Business Case - Building Information Modelling: British Standards Institution, Retrieved from <http://www.hfms.org.hu/web/images/stories/BIM/FreeReport-BIM.pdf>.
- buildingSMART Australasia. (2012). National Building Information Modelling Initiative, Volume 1: Strategy: Department of Industry, Innovation, Science, Research and Tertiary Education.

- CabinetOffice. (2011). Government Construction Strategy.
- Cohen, J. (2010). Integrated Project Delivery: Case Studies: AIA California Council, Sacramento, CA, USA.
- Cohen, L., Manion, L., and Morrison, K. (2013). *Research methods in education*: Routledge 113572203X
- Construct IT. (2008). Strategic positioning of IT in construction. An industry leader's perspective. *Construct IT for Business, Salford, UK*.
- Constructing Excellence. (2004). Partnering *Factsheet*: Constructing Excellence: Retrieved from:  
[http://www.constructingexcellence.org.uk/pdf/fact\\_sheet/partnering.pdf](http://www.constructingexcellence.org.uk/pdf/fact_sheet/partnering.pdf).
- Constructing Excellence. (2012). 2012 UK Construction Industry KPIs - Industry Performance Report.
- Construction Industry Board. (1997). Partnering in the Team. *Construction Industry Board Working Group, 12*.
- Cooper, R., Kagioglou, M., Aouad, G., Hinks, J., Sexton, M., and Sheath, D. (1998). *The development of a generic design and construction process*. Paper presented at the European Conference, Product Data Technology (PDT) Days 1998, Building Research Establishment, Watford, UK
- CRC Construction Innovation. (2007). Adopting BIM for facilities management: Solutions for managing the Sydney Opera House *Cooperative Research Center for Construction Innovation, Brisbane, Australia*.
- Creswell, J. W. (2002). Educational research: Planning, conducting and evaluating, quantitative.
- Crotty, R. (2011). *The Impact of Building Information Modelling: Transforming Construction*: Routledge 0415601673
- CURT. (2010). BIM Implementation: An Owner's Guide to Getting Started: The Construction Users Roundtable. Retrieved from:  
<http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab085571.pdf>.
- Davidson, A. R. (2009). A Study of the Deployment and Impact of Building Information Modelling Software in the Construction Industry *Student Papers*: Faculty of Engineering, University of Leeds, UK, Issue 1, Autumn.
- Denscombe, M. (2010). *The Good Research Guide: For Small-Scale Social Research Projects: for small-scale social research projects*: McGraw-Hill International 0335241387
- Drucker, P. F. (1999). *Innovation and entrepreneurship*: HarperCollins 0066620201
- Easterby-Smith, M., Thorpe, R., and Jackson, P. (2012). *Management research*: Sage Publications 0857021176
- Eastman, C., Teicholz, P., Sacks, R., and Liston, K. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*: Wiley. com 111802169X
- ECTP. (2012). Building Up Infrastructure Networks of a Sustainable Europe Strategic Targets and Expected Impacts: European Construction Technology Platform, Retrieved from:

[http://www.ectp.org/cws/params/ectp/download\\_files/39D2434v1\\_reFINE\\_Targets&Impacts.pdf](http://www.ectp.org/cws/params/ectp/download_files/39D2434v1_reFINE_Targets&Impacts.pdf).

- Edraw. (2014). Edraw Flowchart. Retrieved Access Jan 2014, from <http://www.edrawsoft.com/Data-Flow-Diagrams.php>
- Egan, J. (1998). The Egan Report-Rethinking Construction. *Report of the Construction Industry Task Force to the Deputy Prime Minister*. London.
- Egan, J. (2002). Accelerating change: a report by the strategic forum for construction. *Rethinking Construction*. SF f. Construction, London.
- Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management review*, 14(4), 532-550.
- Faniran, O. O., and Caban, G. (1998). Minimizing waste on construction project sites. *Engineering, Construction and Architectural Management*, 5(2), 182-188.
- Fellows, R. F., and Liu, A. M. (2009). *Research methods for construction*: John Wiley & Sons 1444309455
- Gallaher, M. P., O'Connor, A. C., Dettbarn Jr., J. L., and Gilday, L., T. (2004). *Cost analysis of inadequate interoperability in the US capital facilities industry*: National Institute of Standards and Technology
- Goulding, J., and Alshawi, M. (1999). *Generic IT training: a process protocol model*. Paper presented at the Eighth International Conference on Durability of Building Materials and Components, CIB W78 National Research Council, Ottawa, Canada
- Grimsey, D., and Lewis, M. K. (2004). *Public and private partnerships. The worldwide revolution in infrastructure provision and project finance* 1840647116
- Hamel, J., Dufour, S., and Fortin, D. (1993). Case study methods: qualitative research methods Series 32. *A Sage University Paper*.
- HandsonBridgett. (2010). *Furthering Collaboration Building (in) the Future*: Princeton Architectural Press.
- Harty, C. (2005). Innovation in construction: a sociology of technology approach. *Building Research & Information*, 33(6), 512-522.
- Hecht, L. (2008). A Sustainable Building Industry Requires Service-Based BIM. *V1 Magazine, Promoting Spatial Design for a Sustainable Tomorrow*. <http://www.vector1media.com>.
- HM Government (2012). *Building Information Modelling - Industrial Strategy: government and industry in partnership*.
- Holness, G. V. (2006). Building information modeling: Future direction of the design and construction industry. *ASHRAE Journal*, 48(8), 38-49.
- Hooper, M., and Ekholm, A. (2010). *A Pilot Study: Towards BIM Integration - An Analysis of Design Information Exchange & Coordination*. Paper presented at the CIB W78 - 27th International Conference (16-18 November), Cairo, Egypt
- Hosenfeld, C. (1984). Case studies of ninth grade readers. *Reading in a foreign language*, 231-249.



- Huang, A. L., Chapman, R. E., and Butry, D. T. (2009). Metrics and tools for measuring construction productivity: Technical and empirical considerations *NIST Special Publication 1101*: US Department of Commerce, National Institute of Standards and Technology.
- Ito, K., Law, K. H., and Levitt, R. E. (1990). *PMAPM: an object oriented project model for A/E/C process with multiple views*: Stanford University, Center for Integrated Facility Engineering
- ITP Construction. (2004). Gulf construction boom valued at US \$50 billion. Retrieved <http://www.itp.net/480532-gulf-construction-boom-valued-at-us-50-billion#.Uxq53PmSySo> (8-Mac-2014)
- Jung, Y., and Joo, M. (2011). Building information modelling (BIM) framework for practical implementation. *Automation in Construction*, 20(2), 126-133.
- Kagioglou, M., Cooper, R., Aouad, G., Hinks, J., Sexton, M., and Sheath, D. (1998a). A Generic Guide to the Design and Construction Process Protocol *Final Report*. University of Salford, UK.
- Kagioglou, M., Cooper, R., Aouad, G., and Sexton, M. (2000). Rethinking construction: the generic design and construction process protocol. *Engineering construction and architectural management*, 7(2), 141-153.
- Kagioglou, M., Cooper, R., Aouad, G., Sexton, M., Hinks, J., and Sheath, D. (1998b). *Cross-industry learning: the development of a generic design and construction process based on stage/gate new product development processes found in the manufacturing industry*. Paper presented at the Engineering Design Conference
- Kagioglou, M., Lee, A., Cooper, R., Carmichael, S., and Aouad, G. (2002). *Mapping the production process: a case study*. Paper presented at the Proceedings of International Group for Lean Construction, Gramado, Brazil
- Kats, G. H. (2003). *Green building costs and financial benefits*: Massachusetts Technology Collaborative Boston, MA
- Kumar, R. (2005). *Research methodology: A step-by-step guide for beginners* (2nd ed.): Singapore, Pearson Education
- Kunz, J., and Gilligan, B. (2007). *Value from VDC/BIM Use: Survey Results-November 2007*. Paper presented at the Construction Users Roundtable (CURT) meeting November
- Langdon, D. (2012a). Getting the Most Out of BIM - A Guide for Clients.
- Langdon, D. (2012b). Middle East Construction Handbook 2012.
- Latham, M. (1994). Constructing the team: final report of the government/industry review of procurement and contractual arrangements in the UK construction industry. *The Stationery Office, London*.
- Levene, P., Jackson, N., Gray, R., Jensen, J., Massey, G., Moschini, S., West, R., and Woodman, R. (1995). Construction procurement by government: An efficiency unit scrutiny (the Levene report): London: Efficiency Unit Cabinet Office.
- MacLeamy, P. (2004). The "MacLeamy Curve", illustrates the advantages of Integrated Project Delivery *Introduced in the Construction Users Roundtable's*

*“Collaboration, Integrated Information, and the Project Lifecycle in Building Design and Construction and Operation”.*

- Mactavish, A., and Iqbal, N. (2013). Resources Efficiency Through BIM: A Guide for BIM Managers. In D. Marsh (Ed.), *Guidance on resource efficient construction*. McGraw-Hill Construction. (2007). Interoperability in the construction industry *SmartMarket Report, Interoperability Issue*.
- McGraw-Hill Construction. (2009). IPD - Integrated Project Delivery.
- Merritt, F. S. (1996). Review of Partnering Manual for Design and Construction by William C. Ronco and Jean S. Ronco. *Journal of Architectural Engineering*, 2(3), 122-122.
- Moore, N. (2000). How to do Research: The Complete Guide to Designing and Managing Research Projects. London. *Library Association*.
- Moum, A., Koch, C., and Haugen, T. I. (2009). What did you learn from practice today? Exploring experiences from a Danish R&D effort in digital construction. *Advanced Engineering Informatics*, 23(3), 229-242.
- Naoum, S. G. (2012). *Dissertation research and writing for construction students*: Routledge 0415538440
- NASFA, COAA, APPA, AGC, and AIA. (2010). Integrated Project Delivery for Public and Private Owners.
- National Improvement and Efficiency Partnership. (2012). Client Leadership Guide: NIEP for the Built Environment, Retrieved from: <http://www.niepbuiltenvironment.org.uk/Client%20Leadership%20Guide.pdf>.
- Nelson, M.-M., Lee, A., Cooper, R., Kagioglou, M., and Fleming, A. (1999). *Process Re-engineering in the Construction Industry–Buzzword or Reality?* Paper presented at the Proceedings of the Royal Institute of Chartered Surveyors' 1999 Construction and Building Research Conference
- Neuman, W. L. (1997). Social research methods: qualitative and quantitative approaches. Allyn & Bacon. *Needham Heights, USA*.
- NIBS. (2007). National Building Information Modelling Standard: Version 1 – Part 1: Overview, Principles, and Methodologies *Final Report, December*. National Institute of Building Sciences: Retrieved from: [http://www.wbdg.org/pdfs/NBIMSv1\\_p1.pdf](http://www.wbdg.org/pdfs/NBIMSv1_p1.pdf).
- Osmani, M., Glass, J., and Price, A. D. (2006). Architect and contractor attitudes to waste minimisation *Proceedings of the Institution of Civil Engineers : Waste and Resource Managment* (pp. 65-72): © Thomas Telford Publishing.
- Osmani, M., Glass, J., and Price, A. D. (2008). Architects' perspectives on construction waste reduction by design. *Waste Management*, 28(7), 1147-1158.
- partnerships British Columbia. (2003). An Introduction to Public Private Partnerships: Retrived from: <http://www.partnershipsbcc.ca/pdf/An%20Introduction%20to%20P3%20-June03.pdf>.
- Patton, M. Q. (2005). *Qualitative research*: Wiley Online Library 0470013192

- Rajasekar, S., Philominathan, P., and Chinnathambi, V. (2006). Research methodology. *arXiv preprint physics/0601009*.
- Rethinking Construction. (2002). *Rethinking Construction: 2002, Achievements, next steps and getting involved: Rethinking Construction*. London.
- RIBA. (2007). *RIBA Plan of Work for the Design Team Operation* (4 ed.): The Royal Institute of British Architects
- RIBA. (2012). *BIM Overlay to the RIBA Outline Plan of Work* (D. Sinclair Ed.): London, United Kingdom: RIBA
- RIBA. (2013). *RIBA Plan of Work 2013 Overview: The Royal Institute of British Architects*: Available at: [www.ribaplanofwork.com](http://www.ribaplanofwork.com)
- Richards, M. (2010). *Building information management: A standard framework and guide to BS 1192*: BSI Standards 0580708705
- Robson, C. (2002). *Real world research: a resource for social scientists & practitioner researchers* (2nd ed.): Oxford: Blackwell
- Sala-i-Martin, X., Bilbao-Osorio, B., Blanke, J., Crotti, R., Hanouz, M. D., Geiger, T., and Ko, C. (2012). The Global Competitiveness Index 2012–2013: Strengthening Recovery by Raising Productivity. *The Global Competitiveness Report 2012–2013*, 49-68.
- Saleh, Y., and Alshawhi, M. (2005). An alternative model for measuring the success of IS projects: the GPIS model. *Journal of Enterprise Information Management*, 18(1), 47-63.
- Saluja, C. (2009). *A Process Mapping Procedure for Planning Building Information Modeling (BIM) Execution on a Building Construction Project*. (Master of Science), The Pennsylvania State University.
- Sekaran, U. (1984). *Research methods for managers: a skill-building approach*.
- Sheath, D. M., Woolley, H., Cooper, R., Hinks, J., and Aouad, G. (1996). *A process for change-the development of a generic design and construction process protocol for the UK construction industry*. Paper presented at the NATIONAL CONFERENCE PUBLICATION-INSTITUTION OF ENGINEERS AUSTRALIA NCP
- Shen, G., Brandon, P., and Baldwin, A. (2009). *Collaborative construction information management*: Spon Press
- Singh, V., Gu, N., and Wang, X. (2011). A theoretical framework of a BIM-based multi-disciplinary collaboration platform. *Automation in Construction*, 20(2), 134-144.
- Smith, D. K., and Tardif, M. (2012). *Building information modeling: a strategic implementation guide for architects, engineers, constructors, and real estate asset managers*: John Wiley & Sons 1118399234
- SOM. (2012). Project Management Office (PMO). Available at <http://www.som.cranfield.ac.uk/som/dinamic-content/media/ICPM/PMO4web.pdf>. Accessed on November 2012
- Stebbins, J. (2009). *Successful BIM Implementation: Transition from 2D to 3D BIM. Digital Vision Automation*.

- Strangman, L. (2013). Defining the Research Problem: Available at [www.docstoc.com/docs/158530416/Defining-the-Research-Problem](http://www.docstoc.com/docs/158530416/Defining-the-Research-Problem), Retrieved: July 2013.
- Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction*, 18(3), 357-375.
- Taylor, J. E. (2007). Antecedents of successful three-dimensional computer-aided design implementation in design and construction networks. *Journal of Construction Engineering and Management*, 133(12), 993-1002.
- Taylor, J. E., and Bernstein, P. G. (2009). Paradigm trajectories of building information modeling practice in project networks. *Journal of Management in Engineering*, 25(2), 69-76.
- Teicholz, P. (2004). Labor productivity declines in the construction industry: causes and remedies. *AECbytes Viewpoint*, 4(14), 2004.
- Tellis, W. (1997). Application of a case study methodology. *The qualitative report*, 3(3), 1-17.
- The Stationery Office. (2000). Public Private Partnerships - The Government's Approach: The Stationery Office UK.
- The Strategic Forum for Construction. (2006). 2012 Construction Commitments Retrieved from: [http://www.constructingexcellence.org.uk/pdf/news/2012\\_construction\\_commitments.pdf](http://www.constructingexcellence.org.uk/pdf/news/2012_construction_commitments.pdf).
- Thomassen, M. (2011). *BIM and Collaboration in the AEC Industry*. (Master of Science in Engineering - Management in the Building Industry), Aalborg University, Denmark.
- Thompson, D., and Miner, R. G. (2007). Building information modeling-BIM: Contractual risks are changing with technology Retrieved from: <http://www.aepronet.org/ge/no35.html>.
- Thornton, G. (2013). Global Economy in 2013: Uncertainty Weighing on Growth: Grant Thornton International Business Report, Retrieved from <http://www.gti.org/files/global%20economy%20in%202013%20-%20final.pdf>.
- UKCG. (2009). Construction in the UK Economy: The Benefits of Investment: Study commissioned by the UK Contractors Group and L.E.K Consulting, October.
- VA. (2010). The VA BIM Guide v1.0. Retrieved from: <http://www.cfm.va.gov/til/bim/BIMGuide/downloads/VA-BIM-Guide.pdf>: U.S. Department of Veterans Affairs.
- Vennström, A. (2008). *The construction client as a change agent - Contextual Support and Obstacles*. (PhD Doctoral Thesis), Luleå University of Technology.
- Viewpoint UK. (2004, 16 July 2004). Business Process Modelling using IDEF0. 2013, from <http://www.viewpointtraining.com/vptAccess.html>
- Vom Brocke, J., and Rosemann, M. (2010). *Handbook on business process management 1: Introduction, Methods, and Information Systems*: Springer 3642004164

- Weygant, R. S. (2011). *BIM Content Development: Standards, Strategies, and Best Practices*: John Wiley & Sons 1118030451
- White, S. A. (2004). Introduction to BPMN. *IBM Cooperation*, 2008-2029.
- Willmott Dixon. (2010). The Impacts of Construction and the Built Environment *Briefing Note*: Willmott Dixon Group, Retrieved from: <http://www.willmottdixongroup.co.uk/assets/b/r/briefing-note-33-impacts-of-construction-2.pdf>.
- Winberg, A., and Dahlqvist, E. (2010). *BIM-the Next Step in the Construction of Civil Structures*. (Master Thesis), KTH Sweden. (297)
- Wix, J. (2007). Quick Guide: Business Process Modelling Notation (BPMN): buildingSMART, Norway
- Wix, J., and Karlshoej, J. (2010). Information Delivery Manual: Guide to Components and Development Methods: BuildingSMART International.
- Wolstenholme, A., Austin, S. A., Bairstow, M., Blumenthal, A., Lorimer, J., McGuckin, S., Rhys Jones, S., Ward, D., Whysall, D., and Le Grand, Z. (2009). Never waste a good crisis: A review of Progress since Rethinking Construction and Thoughts for Our Future.
- Yan, H., and Damian, P. (2008). *Benefits and barriers of building information modelling*. Paper presented at the 12th International Conference on Computing in Civil and Building Engineering 2008
- Yin, R. K. (1994). Discovering the future of the case study method in evaluation research. *Evaluation Practice*, 15(3), 283-290.
- Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5): sage 1412960991
- Zainal, Z. (2007). Case study as a research method. *Jurnal Kemanusiaan*(9), 1-6.
- Zerjav, V., and Ceric, A. (2009). *Structuring Communication within Construction Projects—A Communication Breakdown Structure*. Paper presented at the Proceedings of the 25th Annual Conference, Nottingham, UK 7-9 September 2009

## Appendix A: The Interview Questions for Case Study Two and Three

Questions to the Client			
Category	Questions	Comments	Relevant to (Phases)
Client Leadership	<ul style="list-style-type: none"> <li><input type="checkbox"/> What do you think on the setup of the client's committee and their roles and responsibilities?</li> <li><input type="checkbox"/> What do you think the effectiveness of client's committee in monitoring the project progress?</li> <li><input type="checkbox"/> Do you think that the client should setup BIM strategy for the organisation at the early phase of the project?</li> <li><input type="checkbox"/> Do you think that client's organisation should have a separate section or department to deal with BIM implementation such as purchasing or legal department?</li> <li><input type="checkbox"/> What should be the roles and responsibilities of this new BIM office/department?</li> </ul>		
Project brief	<ul style="list-style-type: none"> <li><input type="checkbox"/> What do you think on setting up the project brief? Is it important to the client's organisation?</li> <li><input type="checkbox"/> What are the most important characteristics of the project brief that you think need to be included?</li> <li><input type="checkbox"/> Who do you think should be involved in preparing the project brief?</li> <li><input type="checkbox"/> In which phases the project brief need to be prepared?</li> <li><input type="checkbox"/> Do you think that project brief need to be continuously reviewed by the client's organisation?</li> <li><input type="checkbox"/> Which department(s) should review the project brief and its compliance?</li> </ul>		



Questions to the Client			
Category	Questions	Comments	Relevant to (Phases)
Capacity/ Maturity	<ul style="list-style-type: none"> <li><input type="checkbox"/> What do you think about BIM capacity of the Client's Organisation?</li> <li><input type="checkbox"/> Do you think that BIM capacity is important and should be balanced among the members of the organisation? And Why?</li> <li><input type="checkbox"/> What is the best approach to assess BIM capacity?</li> <li><input type="checkbox"/> Who do you think should do this assessment? And when is the best time to do it?</li> <li><input type="checkbox"/> What is the best approach that you think can be implemented to increase BIM capacity?</li> <li><input type="checkbox"/> Do you think that this approach should be a continuous process throughout the project phases?</li> <li><input type="checkbox"/> How can this approach be implemented?</li> <li><input type="checkbox"/> How do we monitor it?</li> </ul>		
Contracts	<ul style="list-style-type: none"> <li><input type="checkbox"/> Can we identify the type of contract to be used in the project at the very early stage of the project?</li> <li><input type="checkbox"/> What are the requirements for choosing the right contract?</li> <li><input type="checkbox"/> Who do you think should do this earlier selection of the contract?</li> <li><input type="checkbox"/> Do you think that the legal department should prepare the contract agreement and finalise the contract?</li> <li><input type="checkbox"/> Who do you think should monitor the contract progress?</li> </ul>		

Questions to the Client			
Category	Questions	Comments	Relevant to (Phases)
Collaboration	<ul style="list-style-type: none"> <li><input type="checkbox"/> Based on the collaboration level selected, can we determine the type of contract for the project?</li> <li><input type="checkbox"/> When the collaboration levels need to be determined?</li> <li><input type="checkbox"/> Who do you think should facilitate this collaboration?</li> <li><input type="checkbox"/> How this should be monitored?</li> <li><input type="checkbox"/> Should this be included in the contractual arrangement?</li> <li><input type="checkbox"/> Once the collaboration level has been defined, do you think that the selection of BIM partners can be established?</li> <li><input type="checkbox"/> At what phase of the project it should be done?</li> </ul>		
BIM Management	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think BIM standard is important?</li> <li><input type="checkbox"/> Who should set up this BIM standard?</li> <li><input type="checkbox"/> At what phase of the project it should be done?</li> <li><input type="checkbox"/> Do you think that the deliverables, roles and responsibilities of all project stakeholders should be defined at early phase of the project?</li> <li><input type="checkbox"/> At which phase do you think that it best to be defined?</li> <li><input type="checkbox"/> How and who will define it?</li> </ul>		
BIM based applications	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think that the client's organisation should understand the importance of BIM based applications?</li> <li><input type="checkbox"/> Who should decide on the selection of BIM based applications?</li> <li><input type="checkbox"/> At which phase of the project it should be selected?</li> </ul>		



Questions to the Client			
Category	Questions	Comments	Relevant to (Phases)
	<ul style="list-style-type: none"> <li><input type="checkbox"/> How these applications are determined?</li> <li><input type="checkbox"/> Are they related to the project brief</li> <li><input type="checkbox"/> If not, in which part of documents it should be defined?</li> <li><input type="checkbox"/> Who should decide on IT infrastructure of the project?</li> </ul>		
FM	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think that BIM implementation should be linked to FM requirements?</li> <li><input type="checkbox"/> When FM requirements should be identified?</li> <li><input type="checkbox"/> How level of collaboration should be aligned with the FM requirements?</li> <li><input type="checkbox"/> Who should be involved?</li> <li><input type="checkbox"/> How it is linked to project brief</li> <li><input type="checkbox"/> Who will monitor its implementation throughout design and construction phases?</li> </ul>		
Project Phase Decision	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think that a feedback report should be produced at every phase of the project before any decision could be made?</li> <li><input type="checkbox"/> Do you think all data should be recorded at every phase of the project for future use?</li> <li><input type="checkbox"/> What type of data should be recorded?</li> <li><input type="checkbox"/> Who do you think should do this task?</li> <li><input type="checkbox"/> Do you think that at the end of the project, project's feedback should be produced to improve the process and phases?</li> </ul>		

Questions to the Consultant			
Category	Questions	Comments	Relevant to (Phases)
Client Leadership	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think the client's leadership is important in the project? And Why?</li> <li><input type="checkbox"/> What type of roles and responsibilities that you think the client's organisation should play?</li> <li><input type="checkbox"/> When do you think it should be practiced?</li> <li><input type="checkbox"/> What do you think the effectiveness of client's committee in monitoring the project progress?</li> </ul>		
Project brief	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think that the current project brief prepared by client is adequate? If Not, Why?</li> <li><input type="checkbox"/> What is your suggestion?</li> <li><input type="checkbox"/> Do you that it should be linked to BIM development and BIM based applications?</li> <li><input type="checkbox"/> How do you prepare BIM implementation based on project brief?</li> </ul>		
Capability/ Maturity	<ul style="list-style-type: none"> <li><input type="checkbox"/> What is you early perception when your organisation need to use BIM in the project?</li> <li><input type="checkbox"/> Any objections and why?</li> <li><input type="checkbox"/> How do you measure BIM capability/maturity at your organisation?</li> <li><input type="checkbox"/> Do you think who supposed to do that?</li> <li><input type="checkbox"/> What are the preparations that your organisation took in order to improve the capability?</li> <li><input type="checkbox"/> Would you suggest any approach that needs to be adopted to improve the capability?</li> </ul>		

Questions to the Consultant			
Category	Questions	Comments	Relevant to (Phases)
	<input type="checkbox"/> What are the roles of BIM management do you think that can help on improving BIM capabilities?		
Contracts	<input type="checkbox"/> Do you have any problems preparing the contract document using BIM models? <input type="checkbox"/> Is there any different comparing with conventional one?		
Collaboration	<input type="checkbox"/> What is your perception on working in collaborative environment? <input type="checkbox"/> Do you find any difficulties on working in the collaborative environment? <input type="checkbox"/> What is your opinion on the participation of contractor, sub-contractors and suppliers during design stage? <input type="checkbox"/> What is your opinion working on collaboration for resolving clash management issue?		
BIM Management	<input type="checkbox"/> Do you think that BIM management is important? And why? <input type="checkbox"/> What is your opinion on the roles of BIM management? <input type="checkbox"/> Do you think that BIM management should be led by client? <input type="checkbox"/> Do you agree that client organisation should have a separate BIM office/department to deal with BIM management? <input type="checkbox"/> What other expectations that are lacking from BIM management that you would suggest to?		

Questions to the Consultant			
Category	Questions	Comments	Relevant to (Phases)
	<ul style="list-style-type: none"> <li>❑ What do you think the role of BIM management on clash management issues?</li> <li>❑ Would you suggest any procedure/ approach on order to improve BIM management process?</li> </ul>		
BIM based applications	<ul style="list-style-type: none"> <li>➤ What is your early perception when your organisation needs to deal with BIM-based application?</li> <li>➤ What are your preparations for BIM-based applications?</li> <li>➤ Do you have any difficulties on selecting and dealing with BIM based application?</li> <li>➤ Does your organisation have difficulties on setting up IT infrastructure for BIM based application?</li> <li>➤ What are your staff perceptions on BIM-based applications?</li> <li>➤ Do you see any improvement on the productivity using BIM-based applications compare to conventional method? Why?</li> </ul>		
FM	<ul style="list-style-type: none"> <li>➤ What is your opinion on early involvement of facility management department during early design stage?</li> <li>➤ Do you think that BIM implementation should be linked to FM requirements?</li> <li>➤ Any other suggestions related to FM?</li> </ul>		

Questions to the Consultant (MEP)			
Category	Questions	Comments	Relevant to (Phases)
Capability/ Maturity	<ul style="list-style-type: none"> <li><input type="checkbox"/> What is your early perception when your organisation need to use BIM in the project?</li> <li><input type="checkbox"/> Any objections and why?</li> <li><input type="checkbox"/> How do you measure BIM capability/maturity at your organisation?</li> <li><input type="checkbox"/> Do you think who supposed to do that?</li> <li><input type="checkbox"/> What are the preparations that your organisation took in order to improve the capability?</li> <li><input type="checkbox"/> Would you suggest any approach that needs to be adopted to improve the capability?</li> <li><input type="checkbox"/> What are the roles of BIM management do you think that can help on improving BIM capabilities?</li> </ul>		
Project brief	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think that the current project brief prepared by client is adequate? If Not, Why?</li> <li><input type="checkbox"/> What is your suggestion?</li> <li><input type="checkbox"/> How it can be linked to BIM development and BIM based applications?</li> <li><input type="checkbox"/> How do you prepare BIM implementation based on project brief?</li> </ul>		
Collaboration	<ul style="list-style-type: none"> <li><input type="checkbox"/> What is your perception on working in collaborative environment?</li> <li><input type="checkbox"/> Do you find any difficulties on working in the collaborative environment?</li> </ul>		

Questions to the Consultant (MEP)			
Category	Questions	Comments	Relevant to (Phases)
	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you have any problems on developing LoD300 BIM models?</li> <li><input type="checkbox"/> What is your opinion working on collaboration for resolving clash management issue?</li> <li><input type="checkbox"/> What is your opinion on the participation of contractor, sub-contractors and suppliers during design stage?</li> </ul>		
BIM Management	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think that BIM management is important? And why?</li> <li><input type="checkbox"/> What is your opinion on the roles of BIM management?</li> <li><input type="checkbox"/> Do you think that BIM management should be led by client?</li> <li><input type="checkbox"/> Do you agree that client organisation should have a separate BIM office/department to deal with BIM management?</li> <li><input type="checkbox"/> What other expectations that are lacking from BIM management that you would suggest to?</li> <li><input type="checkbox"/> What do you think the role of BIM management on clash management issues?</li> <li><input type="checkbox"/> Would you suggest any procedure/ approach on order to improve BIM management process?</li> </ul>		
BIM based applications	<ul style="list-style-type: none"> <li><input type="checkbox"/> What is your early perception when your organisation needs to deal with BIM-based application?</li> <li><input type="checkbox"/> What are you preparations for BIM-based applications?</li> </ul>		

Questions to the Consultant (MEP)			
Category	Questions	Comments	Relevant to (Phases)
	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you have any difficulties on selecting and dealing with BIM based application?</li> <li><input type="checkbox"/> What are your staff perceptions on BIM-based applications?</li> <li><input type="checkbox"/> How do you find the training?</li> <li><input type="checkbox"/> Do you see any improvement on the productivity using BIM-based applications compare to conventional method? Why?</li> </ul>		

Questions to the Contractor			
Category	Questions	Comments	Relevant to (Phases)
Capability/ Maturity	<ul style="list-style-type: none"> <li><input type="checkbox"/> What is your early perception when your organisation needs to use BIM in the project?</li> <li><input type="checkbox"/> Is there any objections and why?</li> <li><input type="checkbox"/> Before you involve in BIM project, how do you measure BIM capability/maturity at your organisation?</li> <li><input type="checkbox"/> Who do you think supposed to measure it?</li> <li><input type="checkbox"/> What are the preparations that your organisation took in order to improve the capability?</li> <li><input type="checkbox"/> Would you suggest any approach that needs to be adopted to improve the capability?</li> <li><input type="checkbox"/> What are the roles of BIM management do you think that can help on improving BIM capabilities?</li> </ul>		
Collaboration	<ul style="list-style-type: none"> <li><input type="checkbox"/> What is your perception on working in collaborative environment?</li> <li><input type="checkbox"/> Do you find any difficulties on working in the collaborative environment?</li> <li><input type="checkbox"/> Did you involve and collaborate at design stage? If Yes, what level of design did you involved?</li> <li><input type="checkbox"/> What is your opinion on your participation during design stage?</li> <li><input type="checkbox"/> Did you understand Level of Development (LoD) and your obligation to expand LoD300 to LoD400 and LoD500?</li> </ul>		

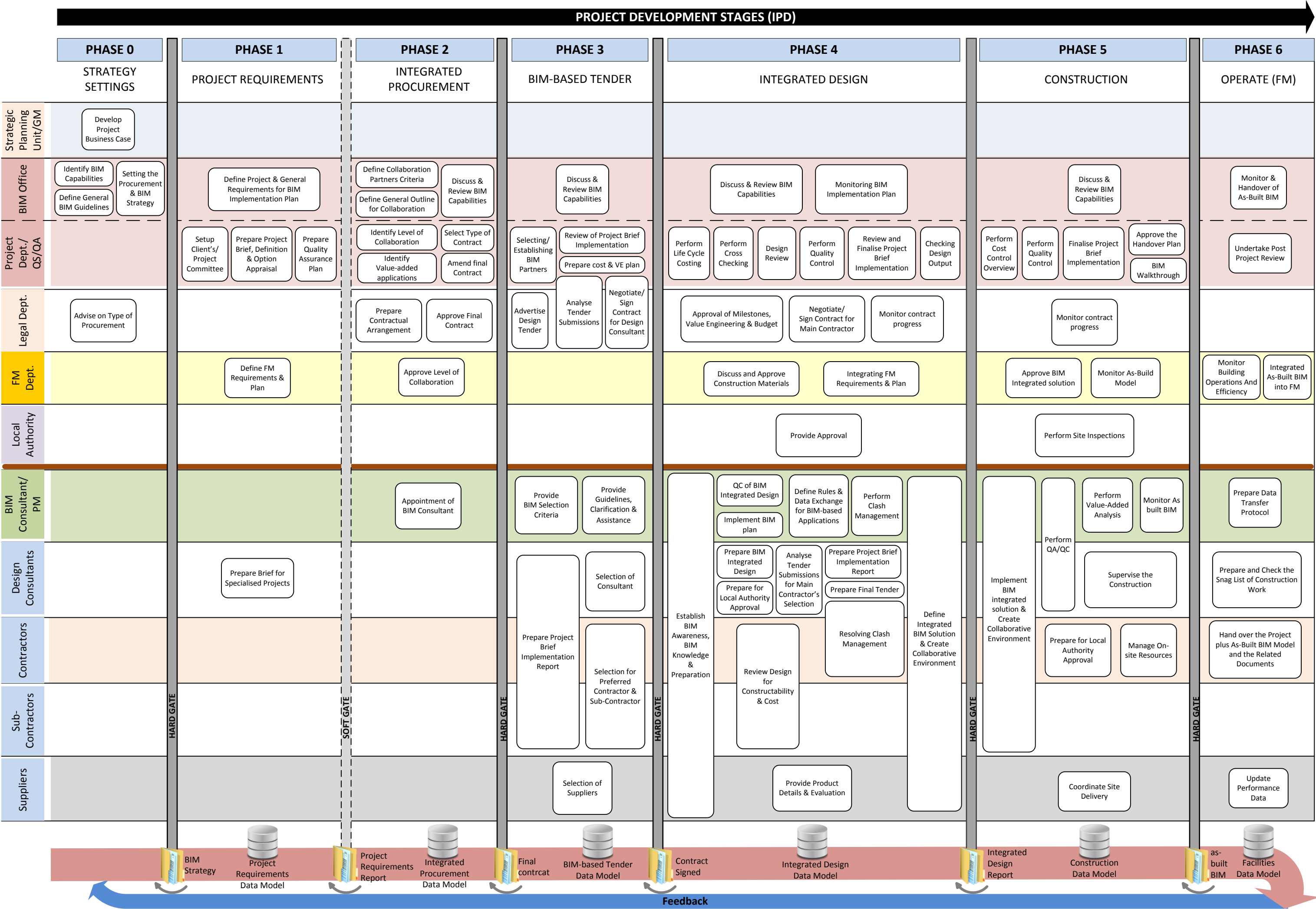


Questions to the Contractor			
Category	Questions	Comments	Relevant to (Phases)
	<ul style="list-style-type: none"> <li><input type="checkbox"/> How do you find the collaboration will help you on developing LoD400 and LoD500?</li> <li><input type="checkbox"/> Do you think continuous collaboration is important throughout the project?</li> </ul>		
Contracts	<ul style="list-style-type: none"> <li><input type="checkbox"/> Is there any difference between conventional contract with and without BIM?</li> <li><input type="checkbox"/> Do you think a different type of contract should be used for BIM and collaborative environment for effective implementation?</li> <li><input type="checkbox"/> Do you have any suggestions for improving the contract procedure or documents?</li> </ul>		
BIM Management	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think that BIM management is important? And why?</li> <li><input type="checkbox"/> What is your opinion on the roles of BIM management?</li> <li><input type="checkbox"/> Do you think that BIM management should be led by client?</li> <li><input type="checkbox"/> Do you agree that client organisation should have a separate BIM office/department to deal with BIM management?</li> <li><input type="checkbox"/> What other expectations that are lacking from BIM management that you would suggest to?</li> <li><input type="checkbox"/> Would you suggest any procedure/ approach on order to improve BIM management process?</li> </ul>		

Questions to the Contractor			
Category	Questions	Comments	Relevant to (Phases)
BIM based applications	<ul style="list-style-type: none"> <li><input type="checkbox"/> What is your early perception when your organisation needs to deal with BIM-based application?</li> <li><input type="checkbox"/> What are your preparations for BIM-based applications?</li> <li><input type="checkbox"/> Do you have any difficulties on selecting and dealing with BIM based application?</li> <li><input type="checkbox"/> Do your organisation have difficulties on setting up IT infrastructure for BIM based application?</li> <li><input type="checkbox"/> What are your staff perceptions on BIM-based applications?</li> <li><input type="checkbox"/> How do you find the training?</li> <li><input type="checkbox"/> Do you see any improvement on the productivity using BIM-based applications compare to conventional method? Why?</li> </ul>		
Client Leadership	<ul style="list-style-type: none"> <li><input type="checkbox"/> Do you think the client's leadership is important in the project? And Why?</li> <li><input type="checkbox"/> What type of roles and responsibilities that you think the client's organisation should play?</li> <li><input type="checkbox"/> When do you think it should be practiced?</li> <li><input type="checkbox"/> What do you think the effectiveness of client's committee in monitoring the project progress?</li> </ul>		

**Appendix B:**

**Process Protocol  
and  
Process Descriptions**



# PROCESS PROTOCOLS DESCRIPTIONS (IPD)

Government/ Client Units	PHASE 0 STRATEGY SETTINGS	PHASE 1 PROJECT REQUIREMENTS	PHASE 2 INTEGRATED PROCUREMENT	PHASE 3 BIM-BASED TENDER	PHASE 4 INTEGRATED DESIGN	PHASE 5 CONSTRUCTION	PHASE 6 OPERATE (FM)
Strategic Planning Unit/GM	<b>Develop Project Business Case</b> <ul style="list-style-type: none"><li>Review project feasibility in terms of time and cost against the benefits (ROI)</li><li>Seeks advice in terms of investment appraisal of the planned project</li><li>Prioritise future projects according to the Strategic Plan</li></ul>						
BIM Office	<b>Identify BIM Capabilities</b> <ul style="list-style-type: none"><li>Identifying maturity level (Determine the capabilities of Team members and organisation)</li><li>People capability/skills (IT and integrating of design and construction)</li><li>Current IT infrastructure</li><li>Realistic assessment of capabilities &amp; capacities</li><li>Define scope of services</li><li>Managing expectations and risk</li><li>Define management of standards</li></ul> <b>Define General BIM Guidelines</b> <ul style="list-style-type: none"><li>Define BIM deliverables</li><li>Define BIM level of detail</li><li>Define BIM objective and responsibility matrix</li><li>Define BIM Modelling and Collaboration Procedures</li><li>Define QA and validation</li><li>Define BIM standards</li></ul> <b>Setting the Procurement &amp; BIM Strategy</b> <ul style="list-style-type: none"><li>Define BIM strategy and Vision</li><li>People/team issues</li><li>Set goals and KPIs</li><li>Implementation/ Management of Change</li><li>Skill identification and upgrading</li><li>Define potential value of BIM</li><li>Define specific BIM uses on potential projects</li><li>Agree on BIM deployment standards and roadmap</li><li>Define possible levels of collaboration</li><li>Define LEED strategies</li></ul>	<b>Define Project and General Requirements for BIM Implementation Plan</b> <ul style="list-style-type: none"><li>Determine BIM modelling requirements</li><li>Define training plans for the concerned Department(s)</li><li>Define BIM implementation plan</li><li>Define project initiation</li><li>Define modelling plan</li><li>Define project collaboration and communication plan</li><li>Define project technology plan</li></ul>	<b>Define Collaboration Partners Criteria</b> <ul style="list-style-type: none"><li>Define collaboration common goals</li><li>Define selection criteria</li></ul> <b>Define General Outline for Collaboration</b> <ul style="list-style-type: none"><li>Define communication protocols</li><li>Define data exchange and sharing</li><li>Define document management &amp; transfer</li><li>Define record storage, etc.</li><li>Define roles and responsibilities</li></ul> <b>Discuss &amp; Review BIM Capabilities</b> <ul style="list-style-type: none"><li>Check level of BIM capabilities of all project stakeholders according to BIM implementation plan</li><li>Check IT readiness according to BIM implementation plan</li><li>Check level of collaboration through BIM capabilities</li></ul>	<b>Discuss &amp; Review BIM Capabilities</b> <ul style="list-style-type: none"><li>Check level of BIM capabilities of all project stakeholders according to BIM implementation plan</li><li>Check IT readiness according to BIM implementation plan</li><li>Check level of collaboration through BIM capabilities</li></ul> <b>Monitor BIM Implementation Plan</b> <ul style="list-style-type: none"><li>Monitor BIM implementation progress &amp; report</li><li>Align BIM progress with the proposed BIM implementation plan</li></ul>	<b>Discuss &amp; Review BIM Capabilities</b> <ul style="list-style-type: none"><li>Check level of BIM capabilities of all project stakeholders according to BIM implementation plan</li><li>Check IT readiness according to BIM implementation plan</li><li>Check level of collaboration through BIM capabilities</li></ul>	<b>Monitor and Handover As-Built BIM</b> <ul style="list-style-type: none"><li>Ensure the expanding use of BIM models throughout the project life cycle</li><li>Ensure to capture and unify the information from BIM models for as built facility</li></ul>	
Project Dept./ QS/QA		<b>Setup Client’s/Project Committee</b> <ul style="list-style-type: none"><li>Identify qualified staffs from client’s organisation</li><li>Identify client representative on-site, PM company and consultants</li><li>Identify &amp; define roles and responsibilities</li></ul> <b>Prepare Project Brief, Definition &amp; Option Appraisal</b> <ul style="list-style-type: none"><li>Define project description</li><li>Define project functionality, e.g. functionality of the building</li><li>Define the equipment and special services/requirements</li><li>Define the project target program Define strategic and design brief</li><li>Define functional brief</li><li>Define financial brief</li><li>Define FM brief</li><li>Define Implementation brief</li></ul> <b>Prepare Quality Assurance Plan</b> <ul style="list-style-type: none"><li>Prepare QA procedures and time frame for both process and product (BIM)</li><li>Review and select appropriate QA/QC standards, procedures and mandates</li><li>Prepare QC process and plan for collaborative design</li></ul>	<b>Identify Level of Collaboration</b> <ul style="list-style-type: none"><li>Define collaboration level(s)</li><li>Define communication methods</li><li>Define document management processes</li><li>Facilitating BIM coordination</li><li>Define record storage, etc.</li></ul> <b>Identify Value-added Applications</b> <ul style="list-style-type: none"><li>Identify available information and data</li><li>Identify possible value-added BIM applications such as cost estimates, ROI, energy analysis, visualisation, construction simulation</li><li>Identify BIM data requirements to support the value-added applications</li><li>Identify other data requirements to support the value-added applications</li></ul> <b>Select Type of Contract</b> <ul style="list-style-type: none"><li>Design-Bid-Build</li><li>Design Build</li><li>Integrated Project Delivery</li></ul> <b>Amend Final Contract</b> <ul style="list-style-type: none"><li>Agree on the collaborator roles and responsibilities</li><li>Ensure contract meets QA standards/requirements</li><li>Agree on final contractual framework and conditions</li></ul>	<b>Selecting/Establishing BIM Partners</b> <ul style="list-style-type: none"><li>Agree on standard/common collaboration protocols</li><li>Select BIM partners who complied with collaboration environment</li><li>Define roles and responsibilities for all BIM partners</li></ul> <b>Review of Project Brief Implementation</b> <ul style="list-style-type: none"><li>Check that tender correctly reflects project brief requirements</li><li>Check submissions against project brief</li><li>Validate functional brief against Client’s “new requirements”</li></ul> <b>Prepare Cost &amp; VE Plan</b> <ul style="list-style-type: none"><li>Develop cost plan</li><li>Prepare Client cost target</li><li>Prepare clear VE guidelines including sharing savings</li><li>Prepare clear VE plan, i.e. when and where VE should be carried out</li></ul> <b>Analyse Tender Submissions</b> <ul style="list-style-type: none"><li>Review submitted tender documentation</li><li>Perform technical evaluation &amp; financial assessment</li></ul> <b>Negotiate/Sign Contract for Design Consultant</b> <ul style="list-style-type: none"><li>Perform direct negotiation</li><li>Prepare contract documents</li><li>Assisting Legal Departments on</li></ul>	<b>Perform Life Cycle Costing</b> <ul style="list-style-type: none"><li>Calculate initial construction cost</li><li>Calculate lifespan of materials and plant</li><li>Calculate service charges</li><li>Calculate replacement costs</li><li>Calculate running costs</li></ul> <b>Perform Cross Checking</b> <ul style="list-style-type: none"><li>Carry out or review BIM based quantity take offs</li><li>Compare quantity take offs and prices to budget</li><li>Ensure design and proposed method of construction does not compromise quality</li><li>Check design requirements to comply with the local authority</li></ul> <b>Design Review</b> <ul style="list-style-type: none"><li>Check according to project brief</li><li>Check the effectiveness and optimisation of the design</li><li>Implement strict design review procedures</li><li>Check design review using 3D visualisation/simulation</li></ul> <b>Perform Quality Control</b> <ul style="list-style-type: none"><li>Implement QA/QC collaborative design review</li><li>Monitor results/outcomes</li><li>Modified QA procedure, if required</li><li>Streamline decision making</li></ul>	<b>Perform Cost Control Overview</b> <ul style="list-style-type: none"><li>Monitor and control budget</li><li>Compare the actual cost with the baseline cost</li><li>Identify cause of the variance</li><li>Updates project document</li></ul> <b>Perform Quality Control</b> <ul style="list-style-type: none"><li>Review and approve contractor submitted quantity take offs after their review by site consultants</li><li>Ensure quality policy is being adhered to</li><li>Inspect construction activities for quality</li></ul> <b>Finalise Project Brief Implementation</b> <ul style="list-style-type: none"><li>Ensure design intent is met or exceeded</li></ul> <b>Approve the Handover Plan</b> <ul style="list-style-type: none"><li>Conduct pre project handover site meeting</li><li>Check contract closeout requirements</li><li>Check all requirement overview – certificates, commissioning, training, as-built models, etc.</li></ul>	<b>Undertake Post Project Review</b> <ul style="list-style-type: none"><li>Schedule the post project review meeting</li><li>Seek individual feedback through a questionnaire</li><li>Prepare post project review report</li></ul>

Government/ Client Units	PHASE 0 STRATEGY SETTINGS	PHASE 1 PROJECT REQUIREMENTS	PHASE 2 INTEGRATED PROCUREMENT	PHASE 3 BIM-BASED TENDER	PHASE 4 INTEGRATED DESIGN	PHASE 5 CONSTRUCTION	PHASE 6 OPERATE (FM)
				technical terms and other requirements	process  <b>Review and Finalise Project Brief Implementation</b> <ul style="list-style-type: none"> <li>Check that design correctly addresses project brief</li> <li>Validate functional brief against Client's "new" requirements</li> </ul> <b>Checking Design Output</b> <ul style="list-style-type: none"> <li>Checking BIM elements are similar to level of detail to the detailed design stage</li> </ul>	<ul style="list-style-type: none"> <li>Check O&amp;M data/info</li> </ul> <b>BIM Walkthrough</b> <ul style="list-style-type: none"> <li>Plan vs actual BIM walkthroughs</li> <li>BIM walkthrough for visual inspections</li> <li>Record BIM walkthroughs for future reference</li> </ul>	
Legal Dept.	<b>Advice on Type of Procurement</b> <ul style="list-style-type: none"> <li>Define risk level &amp; responsibilities among the partners</li> <li>Identify legal constraints</li> <li>Identify potential procurement paths</li> <li>Draft legal/contract agreements</li> </ul>		<b>Prepare Contractual Agreement</b> <ul style="list-style-type: none"> <li>Outline roles &amp; responsibilities of each partner</li> <li>Define clear deliverables according to the level of collaboration</li> <li>Cover all associated legal aspects</li> </ul> <b>Approve Final Contract</b> <ul style="list-style-type: none"> <li>Meeting Collaborative Level</li> <li>Require new contractual clauses</li> <li>Agree roles and responsibilities</li> </ul>	<b>Advertise Design Tender</b> <ul style="list-style-type: none"> <li>Prepare design tender documents</li> </ul> <b>Analyse Tender Submissions</b> <ul style="list-style-type: none"> <li>Review submitted tender documentation</li> <li>Perform technical evaluation &amp; financial assessment</li> </ul> <b>Negotiate/Sign Contract for Design Consultant</b> <ul style="list-style-type: none"> <li>Perform direct negotiation</li> <li>Prepare contract documents</li> </ul>	<b>Monitor Contract Progress</b> <ul style="list-style-type: none"> <li>Design performance reviews</li> </ul> <b>Negotiate/sign contract for main contractor</b> <ul style="list-style-type: none"> <li>Negotiate contract terms with the main contractor</li> <li>Agree on terms &amp; conditions</li> <li>Sign final contract</li> </ul> <b>Approval of Milestones</b> <ul style="list-style-type: none"> <li>Agree on list of milestones and delivery dates</li> <li>Discuss and approve with the Project Dept.</li> </ul>	<b>Monitor Contract Progress</b> <ul style="list-style-type: none"> <li>Construction performance reviews</li> </ul>	
FM Dept.		<b>Define FM Requirements &amp; Plan</b> <ul style="list-style-type: none"> <li>Define FM standards</li> <li>Define space management</li> <li>Define streamlined maintenance</li> <li>Define energy used efficiency</li> <li>Define economical retrofits and renovations</li> <li>Define life cycle renewal</li> </ul>	<b>Approve Level of Collaboration</b> <ul style="list-style-type: none"> <li>Meeting FM requirements</li> <li>Outline project partnering</li> <li>Outline strategic cooperation</li> </ul>		<b>Integrating FM Requirements &amp; Plan</b> <ul style="list-style-type: none"> <li>Integrate FM requirements defined in the design</li> <li>Evaluate energy analysis through BIM models</li> <li>Evaluate ROI analysis through BIM models</li> </ul> <b>Discuss and Approve Construction Materials</b> <ul style="list-style-type: none"> <li>Agree on materials specification</li> <li>Approval final selection</li> </ul>	<b>Approve BIM Integrated Solution</b> <ul style="list-style-type: none"> <li>Approve BIM analysis for FM</li> </ul> <b>Monitor As-Built Model</b> <ul style="list-style-type: none"> <li>Monitor updated BIM model with changes during construction stage</li> </ul>	<b>Monitor Building Operation &amp; Efficiency</b> <ul style="list-style-type: none"> <li>Monitor and compare actual energy demand to design load and predictions</li> <li>Issue preventative maintenance schedule</li> </ul> <b>Integrated As Built BIM into FM</b> <ul style="list-style-type: none"> <li>Accommodate as built BIM data into FM systems</li> </ul>
Local Authority					<b>Provide Approval</b> <ul style="list-style-type: none"> <li>Review submitted drawings, information and details</li> <li>Raise any code violations</li> <li>Issue necessary building permits</li> </ul>	<b>Perform Site Inspections</b> <ul style="list-style-type: none"> <li>Inspect construction elements before erection or pouring of concrete</li> <li>Perform site Health and Safety checks</li> <li>Commission utility connections</li> </ul>	

Project Stakeholders	PHASE 0 STRATEGY SETTINGS	PHASE 1 PROJECT REQUIREMENTS	PHASE 2 INTEGRATED PROCUREMENT	PHASE 3 BIM-BASED TENDER	PHASE 4 INTEGRATED DESIGN	PHASE 5 CONSTRUCTION	PHASE 6 OPERATE (FM)
BIM Consultant			<b>Appointment of BIM Consultant</b> <ul style="list-style-type: none"> <li>Identify independent BIM consultant for BIM management process</li> <li>Identify all BIM roles &amp; responsibilities of BIM consultant</li> </ul>	<b>Provide BIM Selection Criteria</b> <ul style="list-style-type: none"> <li>Identify BIM capabilities of project stakeholders</li> <li>Prepare BIM readiness plan</li> <li>Identify the suitability of BIM software and interoperability</li> <li>Identify share workspaces and databases</li> <li>Select appropriate BIM standards</li> <li>Select appropriate BIM methodologies and processes</li> </ul> <b>Provide Guidelines, Clarification &amp; Assistance</b> <ul style="list-style-type: none"> <li>Check and verify BIM implementation plan</li> <li>Prepare BIM guidelines for BIM execution process</li> <li>Prepare BIM training programmes for</li> </ul>	<b>Establish BIM Awareness, BIM Knowledge &amp; Preparation</b> <ul style="list-style-type: none"> <li>Establish BIM maturity level for the project partners</li> <li>Identify the right BIM teams</li> <li>Prepare a series of BIM awareness programs</li> </ul> <b>Implement BIM Plan</b> <ul style="list-style-type: none"> <li>Establish BIM Change Management</li> <li>Establish steps to BIM adoption</li> <li>Brief BIT on the plan</li> <li>Assist BIT in the implementation of the plan</li> <li>Prepare BIM data</li> </ul>	<b>Implement BIM Integrated Solution &amp; Create Collaborative Environment</b> <ul style="list-style-type: none"> <li>Supply contractor with necessary details to populate BIM</li> <li>Implement BIM-based applications to evaluate construction activities and plans</li> <li>Use integrated BIM to train labours on site activities</li> <li>Identify &amp; share project's objectives</li> <li>Create a work plan to implement collaboration</li> <li>Align the work plan with QA procedures</li> </ul>	<b>Prepare Data Transfer Protocol</b> <ul style="list-style-type: none"> <li>Prepare electronic transfer completed building information</li> <li>Define the specific information required for FM purposes</li> <li>Define the strategy for delivering it</li> </ul>

Project Stakeholders	PHASE 0 STRATEGY SETTINGS	PHASE 1 PROJECT REQUIREMENTS	PHASE 2 INTEGRATED PROCUREMENT	PHASE 3 BIM-BASED TENDER	PHASE 4 INTEGRATED DESIGN	PHASE 5 CONSTRUCTION	PHASE 6 OPERATE (FM)
				BIM capabilities improvement (if required)	<b>QC of BIM Integrated Design</b> <ul style="list-style-type: none"> <li>Establish QA plan for the BIM models</li> <li>Check design, datasets and model properties</li> <li>Perform Interference checks</li> <li>Validate cross-discipline collaboration BIM data</li> </ul> <b>Define Rules &amp; Data Exchange for BIM-based Applications</b> <ul style="list-style-type: none"> <li>Establish process mapping for BIM-based applications</li> <li>Identify data requirements, exchange and rules</li> <li>Identify external data requirements for BIM-based applications</li> </ul> <b>Define Integrated BIM Solution &amp; Create Collaborative Environment</b> <ul style="list-style-type: none"> <li>Define requirements management</li> <li>Define design applications</li> <li>Define comfort simulation of spaces</li> <li>Define energy simulation of buildings</li> <li>Define investment &amp; life cycle costing (LCC)</li> <li>Define environmental analysis</li> <li>Evaluate the lifecycle properties and costs</li> <li>Manage the maintenance and replacement processes</li> <li>Identify &amp; share project's objectives</li> <li>Create a work plan to implement collaboration</li> <li>Implement and cross check all BIM-based applications</li> <li>Design process management</li> </ul> <b>Perform Clash Management</b> <ul style="list-style-type: none"> <li>Provide independent review of clashes</li> <li>Produce and manage clash management process</li> <li>Monitor clashes through out the design phase</li> </ul>	<ul style="list-style-type: none"> <li>Implement and cross check all BIM-based applications</li> </ul> <b>Perform QA/QC</b> <ul style="list-style-type: none"> <li>Check BIM element is modelled with fabrication and assembly details useful for construction works</li> <li>Perform Interference checks</li> <li>Validate cross-discipline collaboration BIM data</li> </ul> <b>Perform Value-Added Analysis</b> <ul style="list-style-type: none"> <li>Perform cost analysis</li> <li>Perform environmental simulation and analysis</li> <li>Perform energy analysis</li> <li>Check constructability</li> <li>Perform Walkthrough simulation</li> </ul> <b>Monitor As built BIM</b> <ul style="list-style-type: none"> <li>Provide final Models that have been updated throughout the construction process</li> <li>Monitor changes and updates that have been communicated from the Contractor to the Design Team</li> <li>Monitor as-built models for space management, building maintenance &amp; modifications</li> </ul>	
Design Consultants		<b>Prepare Brief for Specialised Projects</b> <ul style="list-style-type: none"> <li>Identify additional requirements to be added to project brief</li> <li>Identify special requirements for specialised projects</li> <li>Identify criteria for special services</li> <li>Define additional cost implications for specialised projects</li> </ul>		<b>Prepare Bid and Establish BIM Implementation Team (BIT)</b> <ul style="list-style-type: none"> <li>Identify the potential collaborative partners into BIT</li> <li>Prepare a plan for a series of BIT meetings throughout the project</li> <li>Prepare a plan to establish, implement and monitor the project's BIM implementation roadmap</li> <li>Define and approve partners' roles and responsibility to meet the BIM implementation Roadmap including meeting the agreed collaboration level</li> <li>Evaluate BIM implementation Road Map</li> </ul> <b>Selection of Consultant</b> <ul style="list-style-type: none"> <li>Identify BIM capabilities</li> <li>Identify project track records and BIM experience</li> </ul>	<b>Establish BIM Awareness, BIM Knowledge &amp; Preparation</b> <ul style="list-style-type: none"> <li>Participate in BIM Maturity level study</li> <li>Participate in the BIM awareness program</li> </ul> <b>Prepare BIM Integrated Design</b> <ul style="list-style-type: none"> <li>Prepare an integrated design model ready for on-site construction</li> <li>Specify material and building products, cost environmental impact etc.</li> </ul> <b>Prepare for Local Authority Approval</b> <ul style="list-style-type: none"> <li>Prepare all related documents to be submitted to the authorities for approval</li> </ul> <b>Analyse Tender Submissions for Main Contractor's Selection</b> <ul style="list-style-type: none"> <li>Analyse project cost submission</li> <li>Analyse project track records</li> <li>Carry out technical evaluation of</li> </ul>	<b>Implement BIM Integrated Solution &amp; Create Collaborative Environment</b> <ul style="list-style-type: none"> <li>Supply contractor with necessary details to populate BIM</li> <li>Implement BIM-based applications to evaluate construction activities and plans</li> <li>Use integrated BIM to train labours on site activities</li> <li>Identify &amp; share project's objectives</li> <li>Create a work plan to implement collaboration</li> <li>Align the work plan with QA procedures</li> <li>Implement and cross check all BIM-based applications</li> </ul> <b>Perform QA/QC</b> <ul style="list-style-type: none"> <li>Check Submitted materials</li> <li>Inspect the site</li> </ul>	<b>Prepare &amp; Check Snag List of Construction Work</b> <ul style="list-style-type: none"> <li>Evaluate current construction products</li> <li>Prepare and agree on snag list</li> <li>Agree on process to complete the handover</li> <li>Ensure BIM updates</li> </ul>

Project Stakeholders	PHASE 0 STRATEGY SETTINGS	PHASE 1 PROJECT REQUIREMENTS	PHASE 2 INTEGRATED PROCUREMENT	PHASE 3 BIM-BASED TENDER	PHASE 4 INTEGRATED DESIGN	PHASE 5 CONSTRUCTION	PHASE 6 OPERATE (FM)
					<p>contractors</p> <p><b>Prepare Project Brief Implementation Report</b></p> <ul style="list-style-type: none"> <li>• Prepare project implementation summary</li> <li>• Prepare project schedule results</li> <li>• Prepare project scope &amp; the business solutions</li> <li>• Prepare project detail risk information</li> <li>• Prepare project benefits &amp; highlight changes</li> </ul> <p><b>Prepare Final Tender</b></p> <ul style="list-style-type: none"> <li>• Review project cost, schedule and execution plan</li> <li>• Adjust and prepare general conditions and preliminaries</li> <li>• Assisting in Tender opening and selection</li> </ul> <p><b>Resolving Clash Management</b></p> <ul style="list-style-type: none"> <li>• Participate in series of workshops</li> <li>• Update design models to resolve clash issues</li> </ul> <p><b>Define Integrated BIM Solution &amp; Create Collaborative Environment</b></p> <ul style="list-style-type: none"> <li>• Define requirements management</li> <li>• Define design applications</li> <li>• Define comfort simulation of spaces</li> <li>• Define energy simulation of buildings</li> <li>• Define investment &amp; life cycle costing (LCC)</li> <li>• Define environmental analysis</li> <li>• Evaluate the lifecycle properties and costs</li> <li>• Manage the maintenance and replacement processes</li> <li>• Identify &amp; share project's objectives</li> <li>• Create a work plan to implement collaboration</li> <li>• Implement and cross check all BIM-based applications</li> <li>• Design process management</li> </ul>	<ul style="list-style-type: none"> <li>• Check the updated BIM model</li> </ul> <p><b>Supervise the Construction</b></p> <ul style="list-style-type: none"> <li>• Approve of shop drawings and details added to BIM</li> <li>• Approve of updates to BIM model</li> </ul>	
Contractor				<p><b>Prepare Bid and Establish BIM Implementation Team (BIT)</b></p> <ul style="list-style-type: none"> <li>• Identify the potential collaborative partners into BIT</li> <li>• Prepare a plan for a series of BIT meetings throughout the project</li> <li>• Prepare a plan to establish, implement and monitor the project's BIM implementation roadmap</li> <li>• Define and approve partners' roles and responsibility to meet the BIM implementation Roadmap including meeting the agreed collaboration level</li> <li>• Evaluate BIM implementation Road Map</li> </ul> <p><b>Selection of Preferred Contractor &amp; Sub-Contractor</b></p> <ul style="list-style-type: none"> <li>• Identify BIM capabilities</li> <li>• Identify project track records and BIM experience</li> </ul>	<p><b>Establish BIM Awareness, BIM Knowledge &amp; Preparation</b></p> <ul style="list-style-type: none"> <li>• Participate in BIM Maturity level study</li> <li>• Participate in the BIM awareness program</li> </ul> <p><b>Review Design for Constructability &amp; Cost</b></p> <ul style="list-style-type: none"> <li>• Provide feedback on the constructability of the design</li> <li>• Provide alternative materials and related costs</li> <li>• Engage in value engineering study</li> </ul> <p><b>Resolving Clash Management</b></p> <ul style="list-style-type: none"> <li>• Participate in series of workshops</li> <li>• Provide input and assist design consultants to resolve clash issues</li> </ul> <p><b>Define Integrated BIM Solution &amp; Create Collaborative Environment</b></p> <ul style="list-style-type: none"> <li>• Define requirements</li> <li>• Define BIM-based applications</li> </ul>	<p><b>Implement BIM Integrated Solution &amp; Create Collaborative Environment</b></p> <ul style="list-style-type: none"> <li>• Supply contractor with necessary details to populate BIM</li> <li>• Implement BIM-based applications to evaluate construction activities and plans</li> <li>• Use integrated BIM to train labours on site activities</li> <li>• Identify &amp; share project's objectives</li> <li>• Create a work plan to implement collaboration</li> <li>• Align the work plan with QA procedures</li> <li>• Implement and cross check all BIM-based applications</li> </ul> <p><b>Prepare for Local Authority Approval</b></p> <ul style="list-style-type: none"> <li>• Prepare all related documents to be</li> </ul>	<p><b>Handover As Built BIM &amp; Document</b></p> <ul style="list-style-type: none"> <li>• Compile all related BIM Models prepared and used</li> <li>• Prepare as-built data for COBie and FM purposes</li> <li>• Incorporate O&amp;M information of major systems &amp; equipment in the BIM model elements</li> </ul>



Project Stakeholders	PHASE 0 STRATEGY SETTINGS	PHASE 1 PROJECT REQUIREMENTS	PHASE 2 INTEGRATED PROCUREMENT	PHASE 3 BIM-BASED TENDER	PHASE 4 INTEGRATED DESIGN	PHASE 5 CONSTRUCTION	PHASE 6 OPERATE (FM)
					<ul style="list-style-type: none"> <li>Define comfort simulation of spaces</li> <li>Define energy simulation of buildings</li> <li>Define investment &amp; life cycle costing (LCC)</li> <li>Define environmental analysis</li> <li>Evaluate the lifecycle properties and costs</li> <li>Manage the maintenance and replacement processes</li> <li>Identify &amp; share project's objectives</li> <li>Create a work plan to implement collaboration</li> <li>Align the work plan with QA procedures</li> <li>Implement and cross check all BIM-based applications</li> <li>Design process management</li> </ul>	<p>submitted to the authorities for approval</p> <ul style="list-style-type: none"> <li>Establish communication protocol with the Local Authority</li> <li>Frequently updates</li> </ul> <p><b>Manage On-Site Resources</b></p> <ul style="list-style-type: none"> <li>Prepare &amp; approve detailed recourse planning schedule</li> <li>Ensure all required resources are available as scheduled</li> <li>Work with the Client on strategic partnership with suppliers</li> <li>Minimise waste on site</li> </ul>	
Subcontractors				<p><b>Prepare Bid and Establish BIM Implementation Team (BIT)</b></p> <ul style="list-style-type: none"> <li>Identify the potential collaborative partners into BIT</li> <li>Prepare a plan for a series of BIT meetings throughout the project</li> <li>Prepare a plan to establish, implement and monitor the project's BIM implementation roadmap</li> <li>Define and approve partners' roles and responsibility to meet the BIM implementation Roadmap including meeting the agreed collaboration level</li> <li>Evaluate BIM implementation Road Map</li> </ul> <p><b>Selection of Preferred Contractor &amp; Sub-Contractor</b></p> <ul style="list-style-type: none"> <li>Identify BIM capabilities</li> <li>Identify project track records and BIM experience</li> </ul>	<p><b>Establish BIM Awareness, BIM Knowledge &amp; Preparation</b></p> <ul style="list-style-type: none"> <li>Participate in BIM Maturity level study</li> <li>Participate in the BIM awareness program</li> </ul> <p><b>Review Design for Constructability &amp; Cost</b></p> <ul style="list-style-type: none"> <li>Provide feedback on the constructability of the design</li> <li>Provide alternative materials and related costs</li> <li>Engage in value engineering study</li> </ul>	<p><b>Implement BIM Integrated Solution &amp; Create Collaborative Environment</b></p> <ul style="list-style-type: none"> <li>Supply contractor with necessary details to populate BIM</li> <li>Implement BIM-based applications to evaluate construction activities and plans</li> <li>Use integrated BIM to train labours on site activities</li> <li>Identify &amp; share project's objectives</li> <li>Create a work plan to implement collaboration</li> <li>Align the work plan with QA procedures</li> <li>Implement and cross check all BIM-based applications</li> </ul>	
Suppliers				<p><b>Selection of Suppliers</b></p> <ul style="list-style-type: none"> <li>Identify BIM capabilities</li> <li>Identify project track records and BIM experience</li> </ul>	<p><b>Establish BIM Awareness, BIM Knowledge &amp; Preparation</b></p> <ul style="list-style-type: none"> <li>Participate in BIM Maturity level study</li> <li>Participate in the BIM awareness program</li> </ul> <p><b>Provide Product Details &amp; Evaluation</b></p> <ul style="list-style-type: none"> <li>Provide designers with product specifications, pricing and Lifecycle costing</li> </ul> <p><b>Define Integrated BIM Solution</b></p> <ul style="list-style-type: none"> <li>Define requirements</li> <li>Define design applications</li> <li>Define comfort simulation of spaces</li> <li>Define energy simulation of buildings</li> <li>Define investment &amp; life cycle costing (LCC)</li> <li>Define environmental analysis</li> <li>Evaluate the lifecycle properties and costs</li> <li>Manage the maintenance and replacement processes</li> </ul>	<p><b>Coordinate Site Delivery</b></p> <ul style="list-style-type: none"> <li>Perform Lean concept</li> <li>Compliance with the specifications</li> </ul>	<p><b>Update Performance Data</b></p> <ul style="list-style-type: none"> <li>Update equipment data</li> <li>Monitor performance of the equipment</li> <li>Report on equipment performance</li> <li>Report of equipment problem or failure</li> </ul>