Civil Engineering

School of Civil and Mechanical Engineering

Development of a Collaborative Contractual Framework for Building Information Modelling Enabled Projects

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This thesis is presented as part of the requirements for the award of the Degree of Doctor of Philosophy of the Curtin University

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contain no material which has been accepted for the award of any other degree or diploma in any university.

Adam Alwash

19th January 2020

Human Ethics

The research presented and reported in this thesis was conducted in accordance with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee, Approval Numbers # RDSE-09-16 and RDSE-09-16-03

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ABSTRACT

It has been widely acknowledged that the construction industry is highly fragmented and has been traditionally adversarial. Over that last 50 years, there have been several government-initiated reports, worldwide, that have sought to enact change within the industry. The need for greater collaboration and communication are leitmotivs have been identified as core issues that need to be improved in the construction industry. As a result, collaborative forms of procurement such as Alliances, Joint Ventures and Integrated Project Delivery have become popular. Also, innovations in technology such as Building Information Modelling (BIM) have emerged as core enablers to facilitate collaboration and communication. While the industry is making strides to adopt such procurement methods and BIM, the underlying contracts and traditional legal structure remain adversarial, which stymies the ability to enact collaboration. This research develops a governance-based framework that aligns the contractual provisions for collaboration with the use of BIM to address this problem. The research determines explicitly the fundamental collaboration principles that need to be incorporated into contracts to support the effective implementation of BIM.

As there has been a paucity of empirical research-based studies that have examined the governance structures needed to support the adoption of BIM, this research takes a qualitative line of inquiry to determine the contextual issues that engender collaboration in practice. The research was undertaken in three-stages to develop a governance-based framework. Initially, 25 in-depth semi-structured interviews with a range of industry practitioners were undertaken to acquire an understanding of the issues that influence the nature of collaboration in BIM-enabled projects. The findings from the interviews were then used to develop a conceptual governance framework to determine the relationships and interactions of the dimensions of collaboration required to improve the performance of BIM-enabled projects. Then, using precedents from case-law, the core dimensions of collaboration that are identified are legitimised and therefore, can be considered in conjunction with existing contract forms. Finally, the developed governance framework was validated by undertaking 15 in-depth semi-structured interviews.

BIM digital technology is a powerful way to address productivity challenges in the construction industry; however it requires teams to work together to improve communication and eliminate mistakes. This study developed a governance solution with due consideration to socio-organisational, process and technology aspects, and presented the effective variables resulting in successful collaborative BIM approach. The research outcome confirms that governing the collaboration process is a prerequisite to achieve a fully integrated and collaborative BIM environment. The proposed governance-based collaboration framework is invaluable as it provides much needed common ground in the focal strand of research on collaboration, and a theoretical point of departure for future researchers in addressing the challenges of collaboration and possibility to amend the current legal structure.

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Publications

Some of this work has been published in ASCE- Journal of Legal Affairs and Dispute Resolution in Engineering and Construction

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Impact and Remedy of Legal Uncertainties in Building Information Modeling

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List of Abbreviations

BIM	Building Information Modelling
FM	Facility Management
AIA	The American Institute of Architects
VDC	Virtual Design and Construction
DBB	Design Bid Build
DB	Design Build
DBO	Design Build Operate
RFI	Request for Information
SI	Site instruction
FIDIC	Federation Internationale des Ingenieurs-Conseils
JCT	Joint Contracts Tribunal
AS 2124	Australian Standards 2124
AS 4000	Australian Standards 4000
MEP	Mechanical, Electrical and Plumbing
AGC	Associate General Contractors
LoD	Level of Development
SBCC	Scottish Building Contract Committee
NEC	The New Engineering Contract
ICE	Institution of Civil Engineers
ECC	Engineering and Construction Contract
RIBA	Royal Institute of British Architects
SMART	Strategic Measurement and Reporting Technique
COBie	Construction-Operations Building Information Exchange
TCC	Technology and Construction Court
CDM	Construction (Design and Management)
CEC	Constructing Excellence Contract
BCC	Built Collaborative Contract
HGGRA	The Housing Grants, Construction and Regeneration Act
SOPA	Construction Industry Security of Payment Act
IP	Intellectual Property
QS	Quantity Surveyor
HVAC	Heat, Ventilation and Air-conditioning
SWOT	Strength, weaknesses, Opportunities and Threats
USA	United states of America
WA	Western Australia

CHAPTER 1 INTRODUCTION

1.1 Research Background

The fragmented nature of the construction industry has resulted in uncoordinated and variable project processes, therefore caused an environment of high risk and uncertainty (Kagioglou et al., 2000). Project processes (eg. Quality, schedule) and associated protocols integrate contracting parties under a common framework; hence risk and uncertainty are of significant importance, and reducing them will lead to successful projects. Building information modelling (BIM) as an emerging technology, with its envisioned benefits is expected to reduce uncertainty and diminish disputes.

Several definitions of BIM are available in normative literature (Aranda-Mena et al., 2009; Love et al., 2014). Tyerman (2013) defines BIM as the creation and digital representation of a federated three-dimensional (3D) model that encompasses various elements of a project, while Shafiq et al. (2013) state that BIM is the first-ever IT-based integrated platform that facilitates the exchange of information in a collaborative environment between various engineering disciplines. Different views of BIM benefits, including cost benefits, effective communication, knowledge transfer and management, intelligence gathering on building performance and real-time monitoring of project performance have been espoused (Azhar, 2011; Barlish & Sullivan, 2012; Eadie et al., 2013; Lu et al., 2012).

BIM can provide significant benefits to the construction industry (Love et al., 2013). Through a common platform, BIM allows access to all contracting parties to commonly exchange procurement, design and construction-related data (Azhar 2011). BIM also enables stakeholders to detect clashes and conflicts from different input sources (Farnsworth et al., 2014). According to Rajendran and Clarke (2011), BIM enhances safety and eliminates construction hazards. According to Eadie et al. (2013) models are maintained and are made accessible to all designers in real-time, where design modifications occur before and during construction, therefore an opportunity for design simulation and improving construction performance exist. Also, BIM provides contractors with robust data to base their quantification of construction elements, which facilitates bidding competitiveness (Olatunji et al., 2010). High level of accuracy, value engineering and associated cost control are BIM's potential outcomes (Porwal & Hewage, 2013), which actively contributes towards maximising client's satisfaction (Olatunji, 2015). Ambiguity in spelling out the scope of work and improper allocation of risks are often encountered during construction causing reasons for differences and contractual disputes. Farnsworth et al. (2014) present a case confirms that BIM utilisation has led to detect design error prior to commence construction, which in turn prevented substantial change order, and avoided possible litigation. Integrating BIM with facility management systems prior to project turnover enables reliable data exchange process, where validated designs and verified as-built drawings transfer into operation, and hence benefits operation performance remarkably (Kasprzak & Dubler, 2012). Full facility management integration ensures effective operational workflow, where performance is monitored in real-time with on-time decisions making to achieve value for money (Love et al., 2015).

Eadie et al. (2013) link BIM to enhancing construction accuracy, improving design processes and reducing waste (materials, cost and resources) and creating sustainable communities. However, cross-sectional challenges obstruct the full implementation of BIM. Challenges such as document-based information exchange, lack of education/training and resistance to change result in an insufficient collaboration which subsequently impact data and process management negatively.

According to Arayici et al. (2011), multidisciplinary collaboration is the primary function of BIM as it enables disciplines to integrate their work effectively. Similarly, Aranda-Mena et al. (2009) indicate that BIM improves information management; however, outcomes are only best when standards and systems across disciplines are interoperable. Thus, BIM should not be treated in isolation as a software tool, but rather as a virtual process that combines contributions from project stakeholders throughout the development processes (Azhar 2011).

Design team members collaborate through a virtual process to build a single and virtual model that encompasses all aspects, disciplines and systems of a facility before breaks ground (Azhar, 2011). Therefore BIM encourages integration of all stakeholders and optimise efficiency. Volk et al. (2013) clarify that BIM as shared digital representation of real buildings and information management hub forms a reliable basis for informed decisions beyond design and into construction, maintenance and decommissioning stages.

Another challenge that impedes the successful implementation of BIM is the absence of the collaborative nature in all conventional contract forms. The literature indicates that the nature of doing business in construction is highly adversarial, being 'characterised by a high level of industrial and contractual disputations' (McGrath & Thompson, 1997). Construction projects are being implemented with conventional legal instruments (e.g. conditions of contract, contractual obligations, contract forms and language) that are pre-date BIM. As a result, significant knowledge gaps have evolved around BIM implementation using conventional contract forms. A holistic understanding of contract requirements in a collaborative environment is needed to move toward a new order in construction law that can accommodate BIM.

The absence of contract instruments tailored and dedicated to BIM's collaborative platforms result in reducing BIM deliverables to non-contractual items (Olatunji & Akanmu, 2014b). Thus, developing a BIM contract instrument is an invaluable tool. Without it, BIM projects are unlikely to deliver outcomes that are different from adversarial relationships; however, understanding of the concept of multidisciplinary collaboration is needed. The implementation of BIM in the industry requires support for collaboration among project participants and supply chain integration, and unless setting up collaboration and integrating the whole delivery process and the teams are implemented and maintained, mandating BIM only does not work.

The overarching focus of this study is to investigate the various challenges that hinder collaboration and present a framework for multi-disciplinary collaboration and its main components and their influence on BIM implementation. In addition to that, present a governance model that addresses the issues of collecting data efficiently, managing data effectively, sharing data lawfully and appropriately, and ensuring effective security and intellectual property protection throughout the lifecycle process. The objective of this model is to facilitate collaboration on BIM-based projects around a common and integrated supply chain.

This research has defined a strategy on how to support BIM as a process by addressing the challenges related to it. Organisations need collaborative process to develop their construction projects. The solution is to define collaboration, achieving an overview of the contents of the three categories: people, process and technology (figure 7.1). As the three affects each other they must be considered in relation to one another. Based on the research findings, the socio organisational and people category must be defined in a model structure scheme (figure 7.2), another schemes for process category (figure

7.3) and technology, information accessibility (figure 7.4). By assessing the variables associated with each category, a more clear structure on the required collaboration between participants can be prescribed (figure 8.1). Precise agreements between project stakeholders can be made when their project involvement is defined. The AEC sector needs to consider the collaboration framework presented by this research when adapting to BIM, and amendments to the existing contract forms are needed to do so.

1.2 Research Gaps

Building Information Modelling (BIM) until recent years refers to the use of parametric CAD models for design analysis. The 3D tools of BIM have been used in various applications, and their benefits in commercial construction were subject to research and study (Khanzode et al., 2008). Researchers presented various case studies to assess the feasibility of 3D tools, associated benefits and limitations and their impact on project performance (Haymaker et al., 2001; Staub-French et al., 2001, & Kam et. al., 2003). Ganah et al. (2005) and Akinci et al. (2003) investigated the application of the tools in constructability analysis and resource management, respectively. Other studies investigated the possibility to apply immersive technologies to enhance 3D interaction capabilities (Messner et al., 2006).

Traditional delivery approaches ranging from Design-Bid-Build (DBB) to Design-Build (DB) are still used in various projects in the construction industry (Park & Kwak, 2017). Such delivery approaches normally lead to various challenges, such as:

- presentation of design drawings in 2D format and hence inability to identify clashes and conflicts until after construction commenced;
- delay in construction schedule due to unforeseen clashes and conflicts;
- absence of coordinated drawings and requirement for site measurement which preclude off-site fabrication;
- undesirable rework to address the construction errors resulted from conflicts/clashes;
- substantial number of RFI’s (request for information) and SI’s (site instructions) to ensure corrective actions are taken; and
- reduction in overall productivity and increase in cost/time.

Implementing BIM improve the construction quality and efficiency, which in turn maintain competitive advantage, reduce disputes and provide better services to clients

(Construction, 2012). However, organisations remain reluctant to adopt BIM widely. The transformation from conventional procurement method into digital automation has resulted in various gaps that researches need to address to provoke wider debate on the speed of BIM adoption in the construction industry. Examples are demonstrated below:

- the roles and responsibilities of team members under such sophisticated online collaboration platform and associated liabilities in contract and tort;
- technology integration and managing workflow in organisation and associated business practices;
- the technical mobilisation and early setup requirements for sharing and managing information;
- the collaboration structure and management techniques and processes;
- the legal and security uncertainty associated with an electronic environment; and
- the validity of electronic communication in traditional contracts.

The issues mentioned above will have far-reaching consequences on organisations; however, according to (Abdelkarim, 2010), organisations are restructuring their businesses to implement BIM and to benefit from its promised advantages fully. A study published by (McGraw Hill 2010) confirms that 46% of the architects in Europe maintaining BIM. The reported percentage includes 42% of them creating BIM models. Dodge Data Analytics (2015) projects a sharp increase in contractors implementing BIM in their projects to exceed 68%.

1.3 Research Aim and Objectives

This research aims to develop a collaborative contractual framework for BIM-enabled construction projects, where risks are shared rationally and liabilities are placed equitably among all construction participants. The specific objectives of the research are to:

- identify the characteristics of collaboration in BIM-enabled construction projects;

- compare the characteristics of collaboration in BIM in the context of extant contract conditions in construction projects;
- determine dispute causations around the characteristics of collaboration in BIM in construction projects;
- investigate construction errors resulted from conflicts/clashes and undesirable rework;
- develop and evaluate a framework for constructing BIM's collaborative contract language for construction projects.

In summary, this research will contribute to the normative literature through the development of an information governance model within the qualitative context.

1.4 Research Significance and Motivation

Dodge Data Analytics (2015) reported that the percentage of contractors that are implementing BIM on 30% or more of their projects has increased from n average of 39% in 2013 to 69% in 2015 and is expected to increase more. China is expected to have 108% growth over the next two years. 136% growth is the forecast in the UK, which can be substantiated by the government mandate for BIM on public projects started in 2016. Future growth forecast in well-established regions like US, Canada, Germany and France appears to be slow as firms are already fully engaged. Such increase suggests that organisations are appreciating BIM's benefits. However, other studies in literature claim that BIM is yet to be widely spread. Such slow adoption is attributed to various legal shortfalls associated with BIM.

Understanding the characteristics of collaboration associated with BIM explains the significance of this pioneering research. Conflicts between BIM's fundamental requirements and current legal legislation will be appreciated. Thus new contractual and procedural system will be presented with provisions designed to accommodate BIM with no constraint. Clients and contractors will significantly benefit from such an outcome. Construction industry will witness a transition toward better work quality during design, construction and facility management phases. Contracting parties in BIM-enabled project are provided with a clear understanding of their scope of work, thus diminish chances of differences. Clarity will ultimately save substantial costs should contractual disputes are resolved via regular disputes resolution techniques. The significance of this research is further demonstrated through the intended correlation between BIM application and traditional contract forms. The research provided additional data supporting the currently available understanding, and highlighted areas of conflict between BIM's as collaborative approach and traditional contract types. Organisations in the construction industry need to face the challenges involved with the implementation and diffusion of BIM more vigorously than any time for the past decade.

In addition to the significance of BIM and the potential added values that BIM promises, this research was further motivated by the collaboration paradigm that the implementation of BIM requires and the associated critical changes in organisations that need to be implemented. The increasing level of awareness in industry spurred by recent mandatory drives that different governments opted to apply have further motivated the research.

1.5 Research Methodology

The study relies on qualitative research approach commenced with an in-depth review of the literature. The research process was reviewed and approved by the Curtin University Human Research Ethics Office (Reference Number RDSE-09-16). The main data collection approach was a semi-structured interview and review of case laws and extant contractual structures. Participants and documents were purposely selected to best address the research questions. Case laws related to the research topic were examined to examine court judgments on various challenges. Industry professionals of sound experience in constriction law were included in the population of interest to discuss precedents related to conflicts between BIM and existing legal and contractual structures. Thus controlling extraneous variation and defining limits for generalising the findings. Case studies were also considered. The variety of data sources enabled dealing with a wide range of evidence and provision of in-depth data that was used to stretch the findings and apply rational generalisation (Yin, 2009). Data analysis was conducted concurrently to build up themes and patterns, and to shape the abstractions that emerge from the process. The scope, research instruments and design are described below.

1.5.1 Research Scope

Aiming to provide a stimulus for meaningful engagement by the construction professionals, the research implemented literature review as the first stage to gain a preliminary understanding and ascertain the current status of BIM implementation and associated challenges. An interview-based research followed the literature review to collect feedback from various interviewees, and in turn, form a grounded understanding (Rudestam & Newton, 2014). All interviews were of semi-structured type, and the population of interest was from a variety of organisations across architectural, structural and engineering services design, project management, and contracting. These practitioners were purposively selected for this research because of their experience and previous involvement in BIM-enabled projects. The steps reported by Oates (2006) for the preparation of semi-structured interviews were implemented while undertaking the research. Accordingly, a semi-structured interview guide was prepared based on which all interviews were conducted. A pre-determined set of questions was developed and used in the interviews.

1.5.2 Research Instrument

The research methodology used in this study has adopted qualitative method strategy. Single research paradigm used to explore the legal shortfalls on BIM and associated impact on construction, and provide rational interpretation to elaborate the findings (Abowitz & Toole, 2009). The philosophical framework of this concept is that due to short of resources dealt with collaboration, it is best to obtain such feedback from BIM experts; enables the researcher to amend the sequence of questions and to ask any additional questions depending on the flow of the interview; and allow the interviewees the opportunity to explore responses, provide additional details and introduce new issues as they deem relevant based on their best experience and knowledge. The research process started with the first stage of data collection for collaboration framework developments and followed by the second stage of model validation. Single research instrument was deployed in this study to achieve the intended research outcomes, and as follows:

- Interviews

The flexibility of semi-structured interviews in designing and refining the questions has actively contributed towards obtaining feedback from key protagonists. This form of interviewing helped resolving the contradictory views and compensated the limitations on statistical analysis. In addition to this, the freedom albeit to a certain extent that this technique allows for the interviewees to express their ideas and highlight issues of interest to them, and for the interviewers to weigh up the credibility of responses have further motivated the authors to implement it.

An important consideration that was taken into account was the interviewer training. The success of the semi-structured interview method relies upon the skills of each interviewer in making some difficult field decisions. Adjusting each interview, for example, to obtain accurate and complete data yet maintaining sufficient standardisation to secure the validity and reliability of data is a major challenge to interviewers and depends upon thorough training (Moser & Kalton 1986).

The training normally focuses on two main areas:

1- Establishing competent use and understanding of the specific interview schedule being used in the study
2- Developing an awareness of the errors or bias which can arise with the personal interview technique

Training begins with a review of the existing literature. When specific work begin on the interview, this background knowledge helps to contextualise the contents and structure of the schedule. Interviewer must have some knowledge of the subject domain being explored to obtain valid and complete data during the interview. Informal practice sessions facilitate the interviewer’s competence in handling the schedule. Audiotapes of “dry runs” are used as self-evaluation tools so that questions and queries could be raised and discussed with the research team. Pilot interview schedule provide valuable experience and forms the basis of subsequent training sessions before the main data collection.

- Data Capture

Interviewing industry experts has enabled the structuring of huge amount of information. Actors from different engineering disciplines shed light on the collaboration and the associated information governance. Senior professionals who have significant experience in construction and BIM projects, in particular, formed the key parties for this research. The interviewees represented 25 different organisations. An initial interview was conducted with a professional from a design consultancy firm who was also a member of buildingSMART. Such interview helped to gain access to other interviewees who found the research extremely important to the BIM implementation debate.

Some interviewees suggested to invite other people held different views on particular issues to participate in the research. Many individuals were selected based on suggestions from other interviewees. At the start of each interview, the purpose of the study was introduced and interviewees were requested to talk about their experience and projects where BIM was utilised. Interview questions were open-ended, starting with the general topics and probing to more detail where necessary. All interviews were recorded using a recorder device. Transcription service provider was engaged to transcript all interviews. Following each interview, the editing process was implemented to check the respondent's feedback and other comments before the coding process. Such arrangement helped to bridge gaps and ensure consistency, thus achieve understandability and completeness. After this, participants were allowed to validate the data after the interviews to prevent misinterpretation (Strauss & Corbin, 1997)

1.6 Thesis Structure

The thesis is structured by 9 chapter topics: Introduction, Collaboration, BIM Review Research Methodology, Governance Framework, Case law, Validation, Discussion and Conclusion and Recommendations. Figure 1.1 indicates the organisation of this thesis, and a summary of each chapter is presented subsequently.

Chapter 2 Collaboration - An in-depth review of the collaboration is presented in this chapter. The chapter is fundamentally divided into six sections: definitions of collaboration, theories of collaboration, frameworks of collaboration, main dimensions of collaboration, inter and intra organisations and technology. In summary, this chapter explains the early understanding of collaboration and associated drivers and mechanisms. Therefore it builds a theoretical foundation for this research on collaboration and information governance framework in BIM-enabled projects

Chapter 3 BIM Review - This chapter provides an overview of BIM definition and promised benefits in the construction industry. The challenges and legal shortfalls that impede BIM implementation are presented and discussed in details in this chapter. Existing contract forms and associated contractual uncertainties are highlighted to consider the incorporation of new clauses to motivate collaboration and hence wider implementation of BIM in construction

Chapter 4 Research Methodology – This chapter introduces the methodological strategy and the process of data collection required for this research. Qualitative approach has been adopted as the main research strategy of this thesis. Therefore semi-structured interviews will be applied to achieve the identified research aim and objectives.

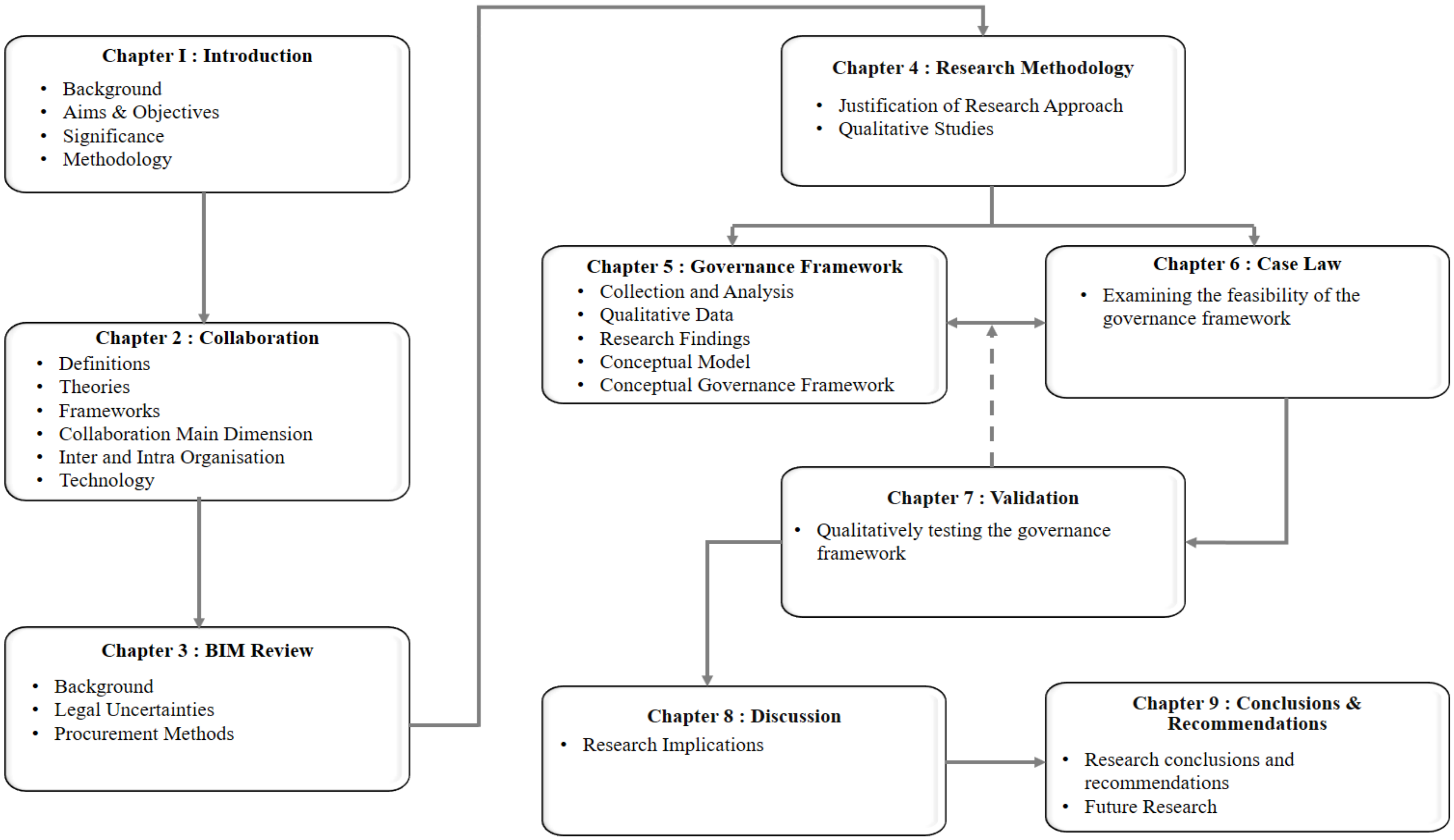


Figure 1. 1 Organisation of the thesis

Chapter 5 Governance Framework - An exploratory study is presented in this chapter. It aims to empirically interpret the prevailing collaboration challenges in the context of BIM. The investigation depends on a series of key-informant interviews with industry professionals. The NVivo12 software was used to analyse the interview transcripts. A governance-based framework was conceptualised as a result of the findings derived from the interviews. The identified framework acts as a conceptual base to understand the impact of collaboration challenges and associated contractual implications on BIM deployment.

Chapter 6 Case Law – The main dimensions of the conceptual framework and associated variables were analysed in this chapter. Voluminous precedent case laws and court judgments were reviewed to test for relevancy and reliability and in turn, strengthen the argument. The complexity of each variable is discussed in this chapter with reference to precedent case-laws in areas of technology, communication and information processes and team management to understand how they interact with complex processes. The outcome of this chapter is very valuable as it forms the foundation of effective factors for adopting BIM within a collaborative environment.

Chapter 7 Validation - A qualitative study is presented in this chapter to validate the proposed framework to suit the actual needs. The study relied on semi-structured interviews with senior management personnel. The conceptual governance-based collaboration framework, which was developed and discussed in chapter 5, has been presented to all participants. The exploratory study presented in this chapter is significant for this research because the proposed framework identifies the interactions between collaboration dimensions and variables that can be used by organisations to build a new structure that would improve their collaborative performance.

Chapter 8 Discussion - Information captured in this research has been structured and consolidated in a collective framework, which denotes the common area that the core dimensions of collaboration share. Such area refers to the optimal collaboration that organisations aim to achieve. Stakeholders must utilise each other’s effort to maximise that common area and achieve optimal collaboration during the use of BIM. This chapter investigates collaboration in the context of standard contract forms such as Joint Contracts Tribunal (JCT) and the FIDIC (International Federation of National Associations of Independent Consulting Engineers). It presents contractual clauses from existing contract forms to highlight the lack of appropriate provisions needed to address the legal concerns.

Chapter 9 Conclusions and Recommendations – This is the final chapter of this thesis, and the key research findings are summarised here. Recommendations that organisations in the construction industry should address to enhance their collaborative performance and achieve BIM full benefits are outlined in this chapter. Also, recommendations for future research are provided.

1.7 Chapter Summary

The implementation of BIM as a multi-disciplinary collaboration platform is challenged with the lack of collaboration between contracting parties. Strategies to suit organisations requirements and practices are required to facilitate information exchange and hence enable team members to contribute and participate in the changing work environment. The primary aim of this research concerning the development of a collaborative conceptual framework was determined and associated objectives were derived in this chapter. Then, the significance and methodology of this research were described and introduced, respectively

This chapter serves a role in providing an overview of this research. There are nine chapters embedded into this thesis, and the core contents of each chapter were summarised above.

CHAPTER 2 COLLABORATION

2.1 Chapter Introduction

This chapter provides a more thorough understanding of the theoretical and practical implications of collaboration and the state of knowledge in the field. To accomplish this task, the chapter began by addressing definitional aspects of collaboration, then exploring theoretical advancements of the field, concluding with examples of the practical applications of the concept. Collection of collaboration theories and frameworks are presented and discussed to synthesize many ideas and discussions in the dynamic study of collaboration, and to gain a better understanding of what facilitates collaboration. In addition, five overarching dimensions that have been identified in this chapter to help provide clarity on the topic.

The relationship between conflicts and collaboration, and how conflict manifests itself in collaborations, through constructive use of communication (driven by culture and emotions) is also addressed in this chapter. Collaboration from organisational process perspective is another important theme that this chapter has discussed. The importance and the definition of cross-boundary information sharing are presented, and associated complexity is reviewed. Situational factors that impact cross-boundary information sharing are illustrated to provide insights to the current information-sharing literature.

Successful collaboration is a process where multidisciplinary team members with complementary skills work together to achieve a common objective that they could not have concluded independently (McNamara, 2012). Poerschke et al. (2010) refer to collaboration as an essential ingredient required for teams to successfully deliver construction projects.

The culture of the construction industry has traditionally been adversarial, with minimal trust between parties on projects, underpinned by an atmosphere of litigation and punitive contracts (Chan et al., 2004; Cheung & Yiu, 2007; Chong & Rosli, 2009). The fragmented approach of the construction industry towards the delivery of any project leads to project teams being characterized by confrontational relationships, a lack of transparency and mistrust. Based on repeated connections between participants, trust is considered as a typical element of collaboration and as stated by Keast et al. (2007) "Collaboration requires much closer relationships, connections, and resources and even a blurring of the boundaries between organisations" (p.19). Alwash et al. (2017) emphasise that collaboration between team members produces a better understanding and avoids an erroneous conception that may lead to undesirable rework.

Literature reveals that communication is critical to the existence and success of collaboration as it promotes dialogue and information sharing (Borden & Perkins, 1999; Johnson et al., 2003), and hence effective stakeholder interaction (Lasker et al., 2001). Additionally, Joint decision-making reduces risk (Innes & Booher, 1999) and promotes representation (Margerum, 2002). Diverse stakeholders and a variety of resources lessen disagreements, and hence integrate into an informed decision making as described by Gray (1989) "a richer, more comprehensive appreciation of the problem" (p.5). Leadership adds legitimacy and credibility as clarified by Ansell and Gash (2008) "essential mediation and facilitation for the collaborative process" (p.550). Shared resources of technical expertise addresses particular interest efficiently, "by combining the individual perspectives, resources, and skills of the partners…creates something new and valuable together, a whole that is greater than the sum of its individual parts" (Lasker et al., 2001, p. 184). Trust is a vital component to sustain collaboration (Huxham, 1996; Mattessich & Monsey, 1992; Morris et al., 2013; O'Leary & Vij, 2012). Ansell and Gash (2008) defines risk as "thick communication" (p.588). Lack of trust does not encourage information sharing and, hence impede collaboration (Dagenais, 2007).

Therefore collaboration is a challenge that to achieve its objectives, a paradigm shift from argumentative culture of litigation and fragmentation to one of information sharing and integrated project delivery is needed.

In addressing these problematic issues, this chapter presents a feasible future direction with recommendations that alleviate individual, environmental, managerial and technological challenges to improve digital coordination and achieve improved design collaboration through the use of BIM.

2.2 The Meaning of Collaboration

A literature review reveals that a lack of consensus on a comprehensive operational definition of collaboration has been acknowledged (Dougherty, 2013). Cheung et al. (2003b) argue that the traditional "confrontational style" in construction exhibited through the adversarial behaviour of participants is the major cause of inefficiency.

Trust is a critical success factor built on a strong degree of expectedness (Nyhan & Marlowe Jr, 1997). Incompetence (Whitley, 1994), failure of integrity and unworthy of information “incomplete, biased or wrong” (Cheung et al., 2003a) are identified as main causes of mistrust in construction. Therefore terms such as alliance, partnering, joint venture become common in the construction industry as an attempt to establish “non-adversarial” relationships between contracting parties, and hence better working environment.

Olsson and Espling (2004) argue that partnering provides a competitive advantage of sharing resources. A study undertaken in Australia by Lenard (1996) suggests that contractual claims are less likely to occur in partnered projects. Yeung et al. (2007) clarify that alliance facilitates sharing risks, hence the creation of a competitive environment. Morledge and Adnan (2005) ascertained that joint ventures provide a market advantage. An atmosphere of trust and mutual respect is created and maintained through early warning systems, open discussion and risk-sharing approach. Team members collectively discuss and alleviate challenges. Every party contributes towards the project’s common objectives under a non-adversarial environment. Collaboration advocates open-communication and joint problem solving, thus is emphasised as an umbrella term to encompass all situations where different parties are involved (Hibbert et al., 2008).

Soetanto et al. (2015) present collaboration as a system where mutual interest are shared between individuals who collectively formulate procedures to regulate and administer their relationships and decision-making process. Dodgson (2018) clarifies that collaboration is a demanding activity requiring a high level of trust and commitment to common objectives.

Poocharoen and Ting (2015) clarify that collaboration is a central tenet for project parties to achieve their objectives efficiently and effectively. It provides a better working environment that retains cost down and reduces litigation (Olsson & Espling, 2004). Johnson (2017) argue that to yield the project’s common goals, all participating agencies need to align their working strategies to facilitate consistency and coherence. Aligning strategies might trigger various set of work activities and other associated contingency relationships that organisations need to coordinate. Coordination of work activities necessitates sharing, integrating and repurposing information between all partiers.

Collaboration is a dynamic and emergent process (Bingham, 2008). It grounded based on democratic participation and deliberation (Koliba et al., 2017). Also, it requires concerted efforts of all participants based on teamwork to deal with strategic and operational challenges (Agranoff & McGuire, 2004). Liu et al. (2017) argue that collaboration is hard to establish and maintain and that team members may pretend to collaborate more than they are doing. Therefore collaboration requires a high-order level of joint action (Olatunji & Akanmu, 2014a).

Various other researches such as Ey et al. (2014); Fulford and Standing (2014) refers to the collaboration as the process that enhances efficiency, integrates resources and improve overall project quality and corresponding financial returns. Mesquita et al. (2017) maintain that collaboration involves interdependence, minimising differences through constructive solutions, shared decision making and joint liability which acknowledges collaboration as a developing process. Organisations engaged in collaboration coinciding prospects regarding their combined actions when reciprocity is maintained. However, failure to execute commitments reciprocally would results in participants tending to take corrective actions to avoid particular consequences, either through formal discussion or by reducing their commitments.

To understand the nature of the efficacy of collaboration phenomena, a definition that encompasses all observable forms and excludes irrelevant issues is needed. A welter of definitions is found in the literature; each offers certain elements. Definitions are detailed next with key characteristics outlined in Table 2.1

Table 2. 1 Collaboration definitions

Definition	Proposed Argument	Reference
"… the hallmark of collaboration is not joint decision making, but joint responsibility for client outcomes."	Relationship between participants are influenced fundamentally by joint accountability. Services offered need to be consistent with best practice in the domain of expertise.	Caplan (1970)
"There is a growing need to promote collaborative problem solving across various sectors of society… organizing such collaborative efforts requires focusing on the interorganisational domain or set of interdependencies which link various stakeholders rather than on the actions of any organization"	Both inter-organizational and inter-sectoral environment with focus on relationships across an inter-organizational domain.	Gray (1985)
"Collaboration is the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own. Collaboration creates a shared meaning about a process, a product, or an	Collaboration as a value creation process to succeed, traditional and hierarchical structures need to be changed. Open communication and mutual trust environment among all collaborators are required to develop a shared sense of the ultimate goals.	Schrage (1990)

event. In this sense, there is nothing routine about it. Something is there that wasn't there before. Collaboration can occur by mail, over the phone lines, and in person. But the true medium of collaboration is other people. Real innovation comes from the social matrix... [and] is a relationship with a dynamic fundamentally different from ordinary communication"		
Collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain	Stakeholders need to achieve some degree of autonomy respect to the roles and responsibilities to ensure that the ultimate outcome is a collaboration not just a merger	Wood and Gray (1991)
" […] a long term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participant's resources. The relationship is based on trust, dedication to common goals	Collaboration refers to the act of working together	Himes (1995)

and an understanding of each other's individual expectations and values. "		
"We have come to see dialogue as the centerpiece of our exchange. We see this as a fundamentally different take on collaboration—one that characterizes sharing and mutuality not in terms of doing the same research work but, rather, in terms of understanding the work of one another"	An emphasis is placed on dialogue as a central shared feature of collaborative work. Collaboration is more than the sum of individual participants. Collaboration cannot be reduced to separate knowledge of the individual participants but a shared knowledge of an emergent form	Clark et al. (1996)
"The principles in a true collaboration represent complementary domains of expertise. As collaborators, not only do they plan, decide, and act jointly; they also think together, combining independent conceptual schemes to create original frameworks. Also, in a true collaboration, there is a commitment to shared resources, power, and talent: no individual's point of view dominates, authority for decisions and actions resides in the group, and work products reflect a blending of all participants' contributions..."	The attributes of the phenomenon includes shared thinking, planning and integrating of information.	John-Steiner et al. (1998)

‘the agreement among specialists to share their abilities in a particular process, to achieve the larger objectives of the project as a whole, as defined by a client, a community, or society at large’	Collaboration entails participants to set aside personal interests, apply professional attitude and maintain training that benefit their roles and comply with the project’s ultimate responsibility matrix	Kalay (1999)
“…collaboration means joint decision making and input, and coercion means unilateral decision making by one party..”	Coercive and collaborative form a dichotomy	Gutkin (1999)
“By accepting that there is nothing individuals can do which cannot be done better by a team, collaboration automatically becomes the highest value which can only be reached by truly listening to other people and adding their valuable contribution.”	In construction context, collective decision making can only be achieved through sharing knowledge and obtaining participants’ buy-in	The toolkit of UK strategic forum for construction (2003) underlined in the integrated project team (IPT) workbook, section 5.5
“A creative process undertaken by two or more interested individuals, sharing their collective skills, expertise, understanding and knowledge (information) in an atmosphere of openness, honesty, trust and mutual respect, to jointly deliver the best solution that meets their common goal”	When what purports to be team collaboration is that group of participants communicate, consult however achieve an outcome that is not the best solution, thus could be a compromise that impacts quality to save time/money rather than the ultimate planned objective	Wilkinson (2005)

“the totality of the results – past present and future – obtained by the laws, norms, rules, and practices of a given discipline . . . There are multidisciplinary and interdisciplinary . . . boundaries . . . however, transdisciplinary has no boundaries”	Methods and viewpoints of different groups are combined and lie across and beyond disciplines	Nicolescu (2010)
“the act of working together; united labour”	Collaborative working is the answer to the low quality of construction and lack of client’s satisfaction	Richmond-Coggan et al. (2001)
“a concept that describes the process of facilitating and operating in multi-organizational arrangements to solve problems that cannot be solved or solved easily by single organizations”	In order to achieve a common objective, project parties of all disciplines need to co-labor, and work together across boundaries.	Poocharoen and Ting (2015)

Examining the elements of the above definitions indicates that the element of working together to address challenges exist across all definitions, and the element related to shared rules/norms is implied across them. Definitions do not assume how many stakeholders will participate, at what level of organisation the collaboration will occur, whether the effort will succeed, what will be the nature of collaboration outcome. These are and will remain empirical questions. The definitions have given guidelines for recognising and distinguishing the phenomena when it occurs.

2.3 Collaboration Theories

The existing literature reveals several established theories of collaboration. Each approach presents different themes with associated essential elements and corresponding weaknesses and strengths. The most commonly referred to are:

2.3.1 Theory of Joint Intentions

The theory of joint intentions proposed by Cohen and Levesque (1990) referred to be the most rational collaboration theory due to its clarity and expression. This theory explicitly includes several key concepts. Shared responsibility and open communication requirements are examples of the concepts. Intention-commitments to act" concept is the basis for this theory. This concept means that when a party becomes aware of any development that is not known to other team members, that party will be obligated to share consciously and deliberately the development in question with the rest of the team. A joint commitment obligates open communication of whatever issue comes to surface and not arbitrary abandoning. Therefore communication between parties becomes vital to the team's success and to achieve the project's joint objectives, and it is domain-dependent.

The cornerstone of this theory is that the communication acts become attempts (requests) because there is a possibility that the act might not wholly succeed in achieving the ultimate intended objective (Smith et al., 1998). For example, if an attempt (request) is initiated by one party to perform a particular task, the receiver might not be able or even refuse to carry out the task. Therefore the attempting party is obligated to retry or utilise an alternative strategy to reinitiate the attempt otherwise cancel the attempt if the receiver has refused to comply. The theory assumes that any receiving party receives an attempt (request) will be committed not only to action but to perform as per the mutually believed objective. Similarly, the initiator of any attempt (request) will be committed to notify the receiver if change deemed to be required or an issue associated with the attempt (request) appeared to be problematic. The mental state of mutual belief “commitment to shared objectives” between parties is sufficient to facilitate the required team interlocking.

Joint intention theory presents a method through which project parties execute their actions jointly. However, a mere message passing will not trigger joint action, but the team must have a starting mutual belief that joint action is commencing. Once joint action commenced, another mutual belief regarding completion, impossibility, or irrelevancy is needed that is associated with the jointly intended action (Kumar et al., 2002). The joint commitment that the theory presents is not a “one-way” social commitment but has to be both ways where any two parties are jointly committed to performing a particular task. Such commitment entails mutual belief that parties must communicate with others.

Team members are not only working together to achieve a common objective but also endeavour to maintain ongoing commitment to the team. Parties in a team help each other when necessary, share relevant information and maintain mutual belief, collectively adopt joint goals and joint intentions, and maintain a mechanism that supports communication and monitoring the execution of the joint plans. Notifying the team when it is appropriate to abandon a team plan is another obligation that needs to be fulfilled by team members.

The theory of Joint Intentions presents the formalisation of persistent joint goals, goals such that all team members are made aware of shared objectives, and committed to notify each other if these objectives are to be abandoned and no longer mutually held.

2.3.2 Theory of SharedPlans

(Grosz, 1990) Discussed several shortfalls and associated impact on collaboration success, and developed a SharedPlan model to account for the identified deficiencies, and hence maintain a successful collaboration throughout the project (Pollack, 1990). The reported shortfalls (Grosz & Kraus, 1996) are listed below:

- an individual action based on a separate plan. Collaboration needs every plan to be an integral part of the joint action. Gluing individual plans together will not lead to successful collaboration;

- lack of shared commitment towards achieving the common goals. Each party needs to be committed to other team members' requirement. Such commitment motivates the obligation to share resources, expertise, and communication to achieve the eventual objectives. Lack of commitment to render assistance if the other party requires it hinders the support for the joint goals; and
- project parties need to share mental state while carrying out partial plans, otherwise dynamic and uncertain world could preclude some part of such plans.

Nguyen and Wobcke (2006) present the SharedPlans model as a formalisation of the mental attitude of team members working together in a project. The theory assumes that a collaborative plan exists, and team members hold certain beliefs, desires and, intentions.

A joint mental state of team members is the implied assumption of this model, where all parties mutually believe to action and address the said shortfalls as follows:

- each party provides the required action on the right time;
- all parties to follow a stipulated plan of actions throughout collaboration;
- each party to contribute towards the overall team's objectives; and
- each party intends to act as required on the right time and as per the plan.

The critical components of mental states of parties when collaboration plan exist to do a group action are as follows:

- individual intentions that the joint action be done;
- individual intentions that parties succeed in performing the identified actions; and
- individual or collaborative plans for actions.

The key components of SharedPlans theory has, however, departed from certain notions that the Joint Intentions theory identified and as follows:

- no assumption or provision for joint intention. In all components, the model prescribing an individual intention that the joint action be done and the success of collaborative actions;

- no allowance is presented for a party to depart his private beliefs from the group if that party wishes so;
- what becomes of the joint action of one party no longer intend to joint action or in case of joint action is no more feasible?; and
- no explicit requirement for communication between parties.

Grosz (1996) state that “Collaboration must be designed into systems from the start; it cannot be patched on.” (p.270). Tambe (1997) further states that “Simply fitting individual agents with precomputed coordination plans will not do, for their inflexibility can cause severe failures in teamwork.” (p.1). Therefore to create collaboration between team members working together on some complex action, the existence of mutual beliefs regarding capabilities, commitments, and implementation of intentions to “to-do intentions and intentions-that certain proposition hold” is required.

2.3.3 Theory of Planned Team Activity

Team formation is the focus of this theory, where opportunity is given to each party to express their interest for a joint commitment (Kinny et al., 1992). Parties are made aware of the collaborative work plan before the project’s commencement. A pre-specifying plan of actions hold each party liable to commit and respond to the requirements in a dynamic environment.

Team leader and other potential members communicate the joint objective, joint collaborative plan, and roles and responsivities of each member. Such communication raises the opportunity for all potential team members to adopt or decline joining the intended project. Kinny et al. (1992) clarify that any party will only to adopt and take the liability to perform as per joint plan when:

3- other team members possess the required skills and competence;
4- the joint goals and the party’s internal goals are aligned;
5- the stipulated roles and responsibilities and the party’s objectives are compatible; and
6- the collaborative work plan unconditionally meets the party’s intentions.

The plans to accomplish in this theory are assumed available to team members before joining the team. Subsequently, all parties become restricted with predictable behaviour that can respond to any dynamic environment. Such an advantage, however, places greater liability on designers to ensure that the plans they specified reflect the desirable conditions. Their success is heavily contingent on how accurate the plans are. The theory also considers two strategies in team formation; commit-and-cancel, and agree-and-execute.

Commit-and-cancel strategy stipulates that each member receives a request to "commit" to the identified joint goal, plan, and specified role. The execution phase commences immediately after receiving the response of "committed" from all members. All members have to send the said response within the permitted time frame. Failure to receive such response from all members leads to cancel the project, and all parties notified with an explicit "cancel" message

Agree-and-execute strategy when all participates receive an "agree" message, followed by an explicit request to execute the plan if all members reply affirmatively. Upon sending the "execute" message, the joint plan, goal, and individual roles become adopted. Refusal to agree to participate by any of the team members does not entail sending the "cancel" message as remaining members have yet to commit to the goals before the "execute" message.

The theory also assumes that any party turns to be unable to execute their part of the plan, should notify the rest of the team. Consequently, a retry can be implemented by amending the plan or even introducing different role assignment before admitting failure (Wilsker, 1996).

In light of the above, the planned team activity model only best fit a predictable environment where qualified team members joint together and fully aware of the pre-enumerated collaborative plans and strategies. Unpredictable domain gives team members a reason to concern about the risk that is associated with any undesirable changes once they adopted the plans. Parties of an opportunistic self-centred behaviour might compromise joint commitment.

2.3.4 Summary

Various parties working together to achieve a common objective is the future domain of all future applications. The collaboration theories and associated ideas to maintain a team share some features in common, albeit, differ in rather significant ways related to communication and team cessation. Three influential contributions to the field have been explored: Joint Intentions, SharedPlans, and Planned Team Activity theories. They represent early serious attempts to formalise collaborative theory with several key concepts. An interesting contrast exists across the theories to illustrate that a unique definition of multi-agent collaboration does not exist.

The notion of contracting, cooperating, and collaborating is also included in the theories. Contracting where a team member appoint another entity to do their work, lacks "shared mental state" towards the common objectives. Cooperation assumes a passive acceptance party's objectives; however, unlike collaboration, it lacks a "shared mental state." Almost all domains in real-world require multiple parties to work together; therefore, to achieve a goal, teamwork is the most expeditious pathway, where interested and capable parties perform various work activities.

The joint intentions framework appears to be the best fit for all working environments. It delivers in-built appeal of robust and dedicated teams with a sense of shared responsibility. Under such a framework, parties, due to different competency levels, might be advantageous for them to contract out some work activities to some other entities based on contractual agreement. However, if specialised knowledge and resources exist, then utilising them to carry out the work is more efficient.

Collaboration theories, however, differ from each other. One theory could be advantageous in a particular working environment and might be second rate in another. Each theory comes with shortfalls that parties have to address to achieve successful collaboration. Comparison of critical principles between the three theories are presented below in Table 2.2

Table 2. 2 Theories critical principles – compare and contrast

Key Principle	Joint Intentions (Cohen)	SharedPlans (Grosz)	Planned Team Activity
Action plan to achieve the desired goal	Generated by the agents	Generated by the agents	Supplied in advance, agents have complete knowledge prior to join the team
Expression of interest to join the team	Not allowed	Not allowed	Allowed
Agent behavior (pre-specifying plans)	Brittle in an unpredictable environment	Brittle in an unpredictable environment	Predictable respond readily to a dynamic environment
Agent designer success	Heavily dependent on plans accuracy and completeness	Heavily dependent on plans accuracy and completeness	Assumed
Joint Intention	Assumed	Not assumed	Conditional
One's private belief mutually believed (departure from joint goal is permitted)	Assumed	Not assumed	Assumed however departure leads to stop executing the whole plan
Joint action if agent no longer intend to it	Vanish	Not assumed	Vanish
Domain dependent communication is implicit	Must	Not required	Must

Note: Vanish means that joint action is no longer exist.

Brittle refers to a risky proposition where opportunistic team members can opt out of a joint commitment is an unpredictable environment.

2.4 Collaboration Frameworks

Collaboration as a dynamic process in a sophisticated organisational setting is impacted by various variables such as leadership, consequential incentives, interdependences and uncertainty (Emerson et al., 2012). A rigorous and empirically grounded conceptual framework is needed to describe these variables, and understand their interactions and therefore ensure that miscommunication, and hence distortion in practice, is prevented. O'Leary and Bingham (2009) clarify that performance, effectiveness, and outcomes need to be studied to evaluate the various forms of collaboration properly.

The level of detail and specificity varies from one collaboration framework to another. Some "frameworks" as termed by Ostrom (2005, p. 8) emphasise the main variables associated with the categories of inputs, processes, and outcomes, and present the connection between them. Other frameworks present hypotheses of how one variable in a category impacts another category. Bryson et al. (2006) argue that trust as a variable in the process category reinforces overall collaboration.

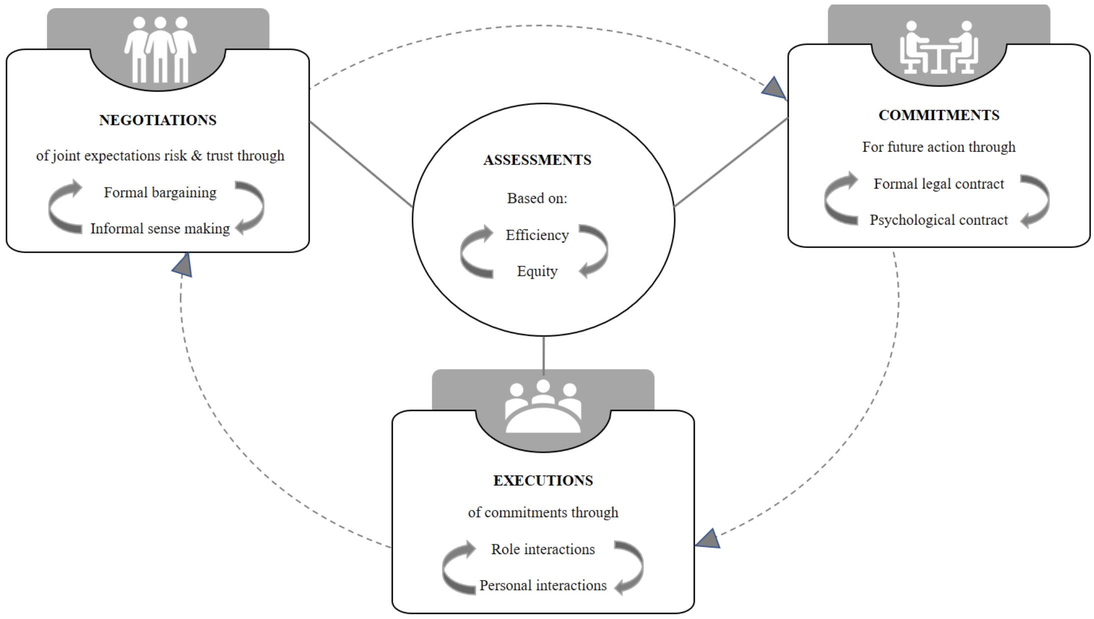
Different system-based collaboration frameworks are reviewed below to understand how collaboration is framed and defined, and hence draw further recommendation:

2.4.1 Early System-Based Frameworks

Gray (1989) developed an early and influential framework where associations between predecessor factors, collaborative forms, and outcomes are expressed. For example, if a conflict is the predecessor driver of collaboration and joint agreement is the expected outcome, then negotiated settlement is the form that the collaboration process will likely implement. A sequential process of problem identification, direction setting, and implementation is the "collaborative form" is such a framework, which all performed by the collaborative parties Gray (1989, p. 9).

Gray (1985) defines domain as a "set of actors that become joined by a common problem or interest" (p.921) and clarifies that the full development process from initial conditions to collaboration is captured in the three-stage process of the above framework.

Ring and Van de Ven (1994) introduce a similar framework (Figure 2.1), which assumes that if negotiation and development of "joint" expectations about inevitable collaboration occur, then implementation of such expectations become commitment. Fulfilling such commitments facilitate mutual understating for further implementation. Failure to achieve the commitments triggers corrective actions to de-escalate the commitments (Thomson & Perry, 2006).



Source : (Ring & Van de Ven, 1994, p. 97)

Figure 2. 1 Inter-organisational relationships framework

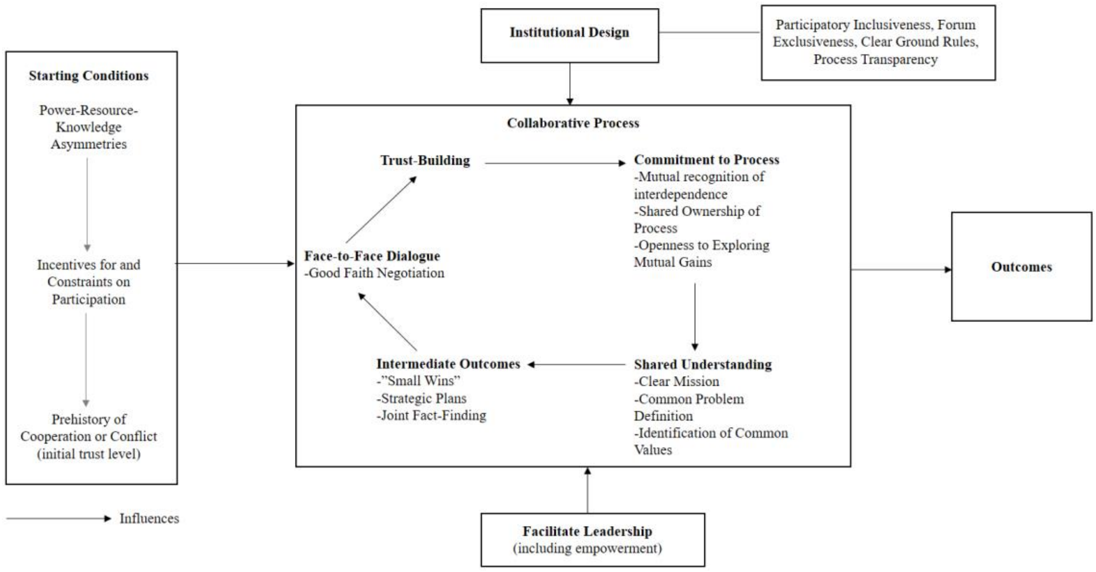
Ring and Van de Ven's framework theorise that individual-level variables such as trust, mutual commitment, and motivation impact rules, policies, and contracts. Therefore, inter-organizational relationships turn out to be more critical than formalised organisational structures.

2.4.2 Collaboration Framework in Public Administration

Governance in the context of public administration is an essential consideration to exercise collective control and influence (Rhodes, 2000). Ansell and Gash (2008) refers to the collaborative governance as "a governing arrangement where one or more public agencies directly engage nonstate stakeholders in a collective decision- making process that is formal, consensus- orientated, and deliberative, and that aims to make or implement public policy or manage public programs or assets" (p.544); and derived a framework that differentiates multi-organizational collaboration when state and nonstate agencies are involved.

Similar to Ring Van de Ven's framework, positive feedback process is incorporated. Communication is a trust enabler and enhances participants' commitment for shared understanding, mutual recognition of interdependence, shared ownership of processes, and understanding of mutual gains. Formal and informal governance and administrative structures created by interacting parties impact the collaborative process and, subsequently, the stability of organisational structures and rules.

Inter-organizational collaborative process is recognised as highly dynamic, impacted by various administrative structures that interacting organisations create (Ansell & Gash, 2008). Other institutional factors, such as formal and informal governance, also impact collaborative process. Figure 2.2 presents the collaborative governance framework



Source: (Ansell & Gash, 2008, p. 550)

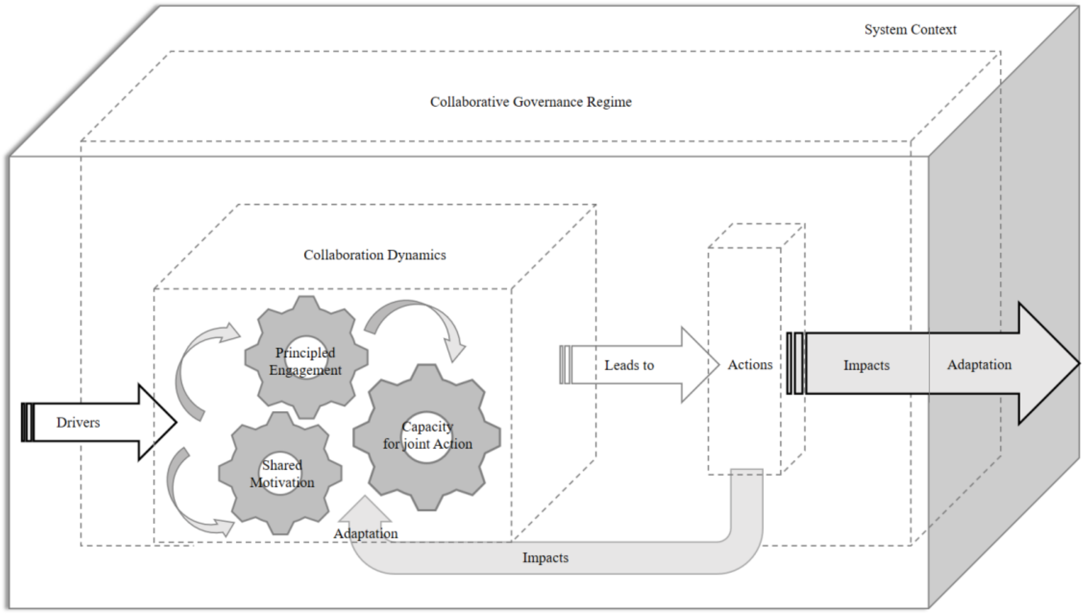
Figure 2. 2 Collaborative framework

Emerson et al. (2012) further refined the collaborative governance regime and proposed a framework in the form of input-process-output. In this framework, collaborative governance is referred to as "processes and structures of public policy decision making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished" (p.2)

The framework of input-process-output differs from other frameworks where it describes complexity as the situational aspect that presents in collaboration. It also considers leadership, consequential incentives, interdependence, and uncertainty as prerequisite conditions to collaboration. The adaptation is specified as a separate outcome of collaboration in that collaboration becomes more sustainable and self-reinforcing when adapt to system contexts and changes in rule structures. The positive feedback, such as motivation, is identified in this framework.

However, authorising collaboration is eventually subject to organisational leadership; therefore, both frameworks focus on the governance level of organisation. Lesser focus on other organisational factors such as resource allocation, shared objectives, and organisational size is placed in the frameworks.

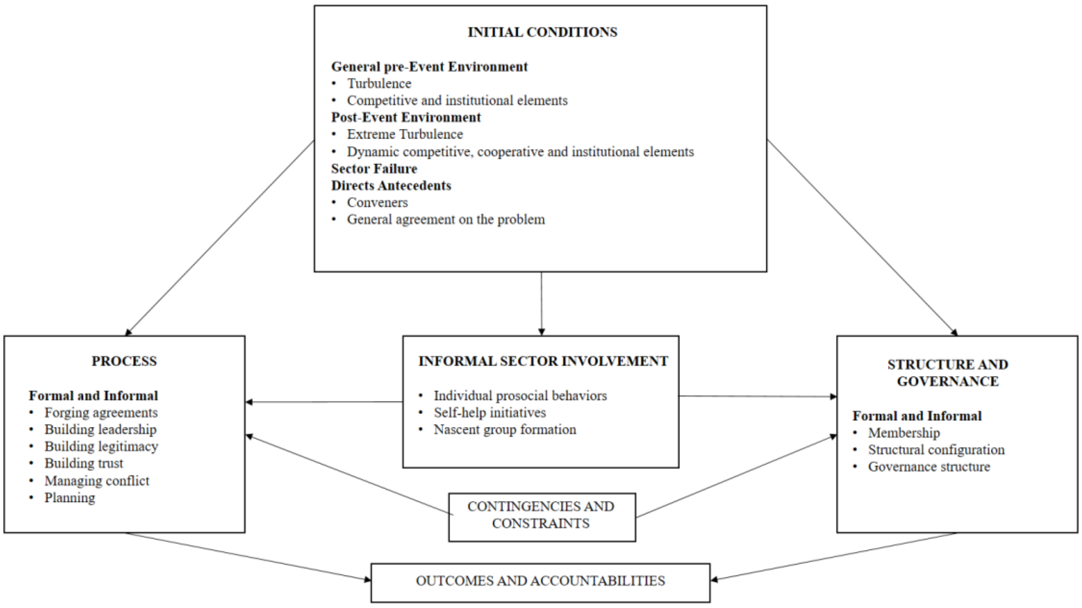
While the frameworks above stress the process of collaboration primarily, surrounding contexts, pre-existing conditions, and outcomes need further discussion. Bryson et al. (2006) developed another framework that expands on the process, and structure, and governance dimensions. In this framework, formal and informal mechanisms are identified to execute inter-organizational agreements and develop leadership legitimacy and trust. Planning and inter-organizational conflict resolution are identified as the main elements of any inter-organizational interface (Lai, 2012). The process dimension is separated from the structural/governance dimension, yet a close relationship between them exists. Figure 2.3 illustrates the framework of input-process-output



Source: (Emerson et al., 2012, p. 6)

Figure 2. 3 Input-process-output framework

Simo and Bies (2007) investigated the cross-sector collaborations as an explanatory dimension for collaborative outcomes. They identified the significance of "informal sector involvement" Simo and Bies (2007, p. 139), where new forms of relationships are essential in collaboration. This theme was further underpinned by another dimension introduced by Morris et al. (2013), which is social capital as the basis of collective action and introduced in two perspectives. The first perspective views social capital as a transactional mechanism between parties, where norms of trust and reciprocity require mutual exchange are to be established. The second perspective refers to the social interactions between all parties across the network that generate social capital (Putnam, 2000). Cross-sector collaboration framework is demonstrated in Figure 2.4



Source: (Simo & Bies, 2007, p. 132)

Figure 2. 4 Cross-sector collaborations framework

2.4.3 Summary

The complexity of collaborative action as a fundamental point is one of the conclusions that can be drawn from reviewing the frameworks. The form of input-process-output is the typical structure for most of the frameworks. Relationships between levels of analysis are suggested.

Most frameworks share the characteristics of adaptation and repetition, permitting changes in processes, participants, and governance structures as a situation develops. While little is specified about how such adaptation might unfold, series of effects that result from collaborative activities are described. Innes and Booher (1999) refer to the creation of social capital, vigorous agreements, advanced solutions, or stable organisations as collaborative outputs. Bryson et al. (2006) describe changes in practices and perceptions as collaborative impacts. Change in culture or norms is considered an indicator of collaboration that could emerge after some time.

Although the general features of collaboration (e.g., shared objectives, mutual benefits, and interdependence) are reflected in all frameworks, it is evident that the use of the term "collaboration" is not consistent. Collaboration is affected by the context, such as the hierarchical organisational level. Some frameworks may only apply to leadership while others spell out roles for all participants; however, drivers and mechanisms of collaboration remain the same except the authority to commit resources that higher-up levels tend to control.

All frameworks consider collaboration as an open system; however, emphasise natural and rational aspects to varying extents. For example, governance and administration structures are specified as essential to the collaborative process (Thomson, 2003). In contrast, aspects of human relations such as legitimacy and power balance of participants and the importance of the mediator roles in collaboration are emphasised by Gray (1989). Contingent on experiences, and identities of participants, collaboration may vary over time quite considerably.

2.5 Collaboration Main Dimensions

Baiden et al. (2003) stress the importance of team integration to improve project procurement and delivery processes and to form one cohesive unit of mutual supporting approach. Integrated approaches require the sharing of information between individuals and experts of different organisations to accomplish a joint project's target. Shen et al. (2010) argue that integration is a continuous process where participants exchange information unreservedly, resulting in a highly effective and efficient collaborative team.

BIM leads to enhance efficacy, productivity, accuracy and cost-effectiveness (Love et al., 2013); however it requires contracting parties to work via integration platforms rather than employing a fragmentation process. Collaborative process is required based on shared risk to carefully addresses challenges and implements solutions (Warner & Sullivan, 2017). Collaborating for collaboration's sake, or for achieving individual goals are likely to fail (Huxham & Vangen, 2013). Therefore it is essential to understand collaboration and its implications.

The literature review facilitated critical evaluation and synthesis of existing knowledge relevant to the collaboration. Through an investigative search and analytical reading of the literature, sufficient familiarity with disciplinary debates and perspectives have been established. The review of literature facilitated an opportunity to immerse into the intellectual endeavour that has been millennia in the making. As a consequence, key ideas and methodologies were identified and discovered such as gaps and anomalies in previous research, important variables relevant to collaboration, relationship between ideas and practice, the context and practical significance of the problem, and the main methodologies and data collection tools that need to be implemented.

As detailed in chapter 5, semi-structured open-ended interviews as a technique to collect qualitative data was applied. The interview as the data gathering technique was to gather as much information as possible from the interviewees as our target population. The open-ended nature of the questions within the structured nature of the interviews was expected to systematically collect useful data for the research. It is considered that open ended questions allow for a variety of responses and fit better with the aim of getting an ‘insider view’ of a situation (Staples & Niazi, 2007). Open ended questions are also expected to avoid introducing any of the researcher’s own preconceptions and protect the validity of the data. The interviewing instrument was designed with the intention of keeping the discussion focused and using the interviewee’s time effectively (Patton, 1990). The structure of the interviewing instrument was designed with the intention of taking each respondent through the same sequence and asking each respondent the same questions with essentially the same words. The benefit of using the open-ended questions in an interview is that data that are systematic and thorough can be obtained (Patton, 1990).

This research presents based on literature review, a model-based collaborative structure (Figure 2.5) that categories and specifies collaboration dimensions, which allows consistent and reliable measurement of the successes and failures of collaboration.

2.5.1 Governance

Partners in collaboration need to have an understanding that governance refers to the acknowledgment of all participants’ opinions on the basis that everyone has a legitimate interest in the project and are entitled to unrestricted access to the information-sharing process (McCaffrey et al., 1995). Such understanding is followed by potential negotiation to achieve mutual agreement that ensures all participants’ approval on the decision once it is made. Accordingly, this facilitates a joint decision-making process based on rules that govern participants’ behaviour and relationships through a shared power arrangement (Brady, 1993). However, working rules need to be developed by participants to ascertain the allowed and constrained actions (Cheng et al., 2006), and to determine any likely sanction that needs to be imposed on any noncompliant participant. As decided in the case of *Hub Group, Inc. vs. Clancy* (2006), in the absence of authorised access, or by exceeding the authorised access, the conduct of accessing confidential information constitutes a claim of damage. Such entitlement accordingly means that the legal system recognises the right of property where unauthorised use of information is considered tortious (see case *Seager vs. Copydex Ltd*, 1967).

The entitlement to claim for damage exists even if the unauthorised access was unintended, however courts inclined to have the confidential information accurately identified and not merely global. In the case of *O'Brien v Komesaroff* (1982), the High Court of Australia ruled against the request to protect an alleged confidential information due to lack of clarity as to which part of that information was not public knowledge. Further to this is the copyright protection, where any creative output cannot be copied without the original author's permission as long as it is presented in a material form and not merely ideas or information.

The defendant, in the case of *Digital Communications Associates Inc vs. SoftKlone Distribution Corp*, (1987) claimed that the status screen function in a computer program is not the subject matter of copyright protection; however, the court rejected his claim. It ruled that the said function involves substantial creativity and granted copyright protection. Such law provisions provide sufficient protection and hence motivate parties in BIM-enabled projects to exchange their information and work collaboratively.

Governance in collaboration is further described as "jointness," where collectively determined rules form the basis of an agreement framework to ensure a collaborative environment (ul Musawir et al., 2017). Therefore, participants need to accept shared responsibility when they engage in collaboration. Accepting shared responsibility allows focus directly on addressing a problem rather than on assigning individual responsibility, and hence moves toward problem-solving rather than problem attributing (Love & Smith, 2016).

Courts also acknowledge shared-responsibility when inherently hazardous operations exist. In the case of *Esso Petroleum ltd vs. Scottish Ministers and others* (2016), the contractor was liable to consider the presence of contaminated land and groundwater; however, construction work caused the contaminants to be disturbed and led to their spreading into the neighbouring land. Lord Tyre held that such components risked health and safety, and ordered that the employer and contractor share responsibility and hence, both were held liable for the damaged incurred. The main lesson here is: an employer cannot relieve himself from liability by binding a contractor to take adequate precautions. Shared authority, joint decision making, and openness to problem-solving are the principles of this dimension, which participants need to understand.

2.5.2 Administration

Moving forward from governance, achieving the collaboration objectives require an administrative framework that facilitates coordination, stipulates roles and responsibilities, and monitors activities development and progress (Patel et al., 2012). Collaboration enables meeting team objectives when individual roles are coordinated toward the same. Coordinating the communication flow and retaining participants' awareness with all collectively determined rules requires a central position within the framework structure. The combination of administrative measures and the culture of social behaviours is critical and hence needs to be correctly balanced to get things accomplished in collaboration (Williams, 2002). Social behaviour includes relationships between participants that are built and sustained effectively.

Huxham and Vangen (2013) clarify that adherence to norms of behaviour shared codes of conduct, and informed responses to development as they unfold, influence communication among participants substantially. Such influence exceeds contractual obligations and that failure of collaboration to achieve its short-term success will result in the likelihood of contract determination. The participants in a collaborative environment form roles and stipulate scope of work to achieve their intended objectives. However, the process to place common-interest above any other self-interest remains the leading administrative principle and critical success factor that collaborative teams need to follow and manage appropriately (Pawlak, 2016).

2.5.3 Autonomy

Parties in collaboration play different roles, however, and managing the inherent tension between self-interest and collective interest is the challenging principle. (Patel et al., 2012) clarify that organisational structure and boundaries influence the level of autonomy, which in turn influence collaborative work. Organisational structure determines policies and stipulates incentives to collaborate and achieve a successful project outcome (Love et al., 2011b)

Tschirhart et al. (2005) clarify that in collaborative work, dual identity is what participants tend to share by sustaining their own identities and their organisational delegated authority separate from the collaborative identity. Dual identity results in an intrinsic tension of autonomy-accountability situation (Huxham & Vangen, 2013), where parties need to validate their engagement in collaboration as a means to achieve their ultimate goals, or otherwise refrain from the whole collaboration process. Through unrestricted access in sharing information, participants share control in collaboration. The exchange of information exceeds the organisation's regular operations to include the actual capability to collaborate. The parties' willingness to share information is the unique characteristic of collaboration that challenges most collaborative teams (Vigoda-Gadot, 2003).

2.5.4 Mutuality

Mutuality is an integrative strategy lead to a win-win solution. Parties in a collaborative work implement such strategy to resolve disputes. Integrative potentials are explored to achieve mutually beneficial agreements based on shared interest, where differences reach a common ground of resolution and hence create greater value. Although openness in information sharing is the differentiating aspect of collaboration, mutual benefits, shared interests and collectively identifying the characteristics in common, are the key factors that drive collaboration to success (Irani et al., 2017).

Shared resources and expertise between parties in collaboration is required to facilitate a successful project outcome. The exchange of resources happens when one party has skilled resources that are of benefit to another party in collaboration. Both parties willingly agree to share resources and to forego any entitlement to claim for personal interest at the expense of others (Powell, 2003). Lack of adequate resources that tasks demand will impede collaboration; therefore, it is essential to consider resource availability and manage access according to demand.

Courts acknowledge that reciprocal rights and obligations are the contractual background of mutuality. In the case of *Electronic Industries Ltd vs. David Jones Ltd* (1954), the High Court of Australia held that parties, if agreed to achieve something, are bound to perform whatever cooperative acts to achieve the contractual objectives even though no express words to that effect exist in the contract. Accordingly, in the case of *Perini Corp vs. Commonwealth* (1969), the Supreme Court of New South Wales ruled that there is an implied duty to cooperate between parties who are in agreement to achieve a particular result. As a result, this means that nothing shall be done to hinder a party performing the contract.

Parties shall do nothing of their volition to prevent or put an end to any circumstances upon which the performance of contract depends (*Downer Connect Pty Ltd vs. McConnell Dowell Constructors (Aust) Pty Ltd,* 2008). Contracting parties under implied liability to cooperate would do whatever is necessary to enable a contractual performance (*Secured Income Real Estate (Aust) Ltd v St Martins Investments Pty Ltd.,* 1979). However achieving such performance is guaranteed (*New South Wales v Banabelle Electrical Pty Ltd,* 2002). Collaboration through the obligation to cooperate is the mechanism that parties require to make their promises work (*Centennial Coal Co Ltd v Xstrata Coal Pty Ltd, 2009).*

2.5.5 Trust and Reciprocity

Fragmentation and lack of collaborative interaction between contractual parties is a fundamental characteristic of the construction industry (Agyekum-Kwatiah). The literature suggests that adversarialism has bedevilled attempts to enhance project performance. Moving away from adversarialism is therefore needed to encourage collaboration and achieve integration, which can be done through mutually beneficial agreements between participants based on shared interest (Bresnen & Marshall, 2000). Trust and reciprocity play a significant role in forming the relationships between participants with substantial prominence placed on shared understandings and dedication to common objectives (Badenfelt, 2010). Reciprocity is also essential and rooted in the shared understanding of cultural and traditional obligation (Powell, 1990).

The New Zealand Court of Appeal recognised the divergence between negotiations and concluded contracts and ruled that good faith should apply to all contracts

(*Wellington City Council vs. Body Corporate*, 2002). Lord Mansfield, in the case of *Carter vs. Boehm* (1766) and Lord Kenyon in the case of *Mellish vs. Motteux* (1792), observed good faith and honesty as high importance elements in all contracts. Courts in the United States place duty of good faith on all contracting parties as part of their contractual performance.

Trust and good faith are concepts of human behaviour that link entitlements and obligations, a project's common interest, and the willingness to cooperate to achieve the ultimate aims. In the context of dispute resolution, Courts oblige parties to act in good faith when it comes to negotiations or mediation to resolve disputes (*Atrzelecki Holdings Pty Ltd vs. Cable Sands Pty Ltd*, 2010; *Computershare Ltd v Perpetual Registrars Ltd,* 2000). In that arena of correctness, Australia's Judges in construction and all other commercial contracts, place duty to exercise genuine attempts to resolve disputes and to cooperate in good faith to enable benefits from contract and fulfilment of obligations (*United Group Rail Services Ltd vs. Rail Corporation (NSW)* 2009; *Nala Engineering Ltd vs. Roselec Ltd,* 1999; *Secured Income Real Estate (Aust) Ltd vs. St Martins Investments Pty Ltd*, 1074; *Peters (WA) Ltd vs. Petersville Ltd*, 2001; *Burger King Corp vs. Hungry Jack's Pty Ltd,* 2001)

In collaboration, individual parties are willing to implement collaborative interactions when other parties express the like. The literature review reveals that trust correlates with the extent to which information is shared between participants. Collective decision making grows in direct proportion to information sharing (Uitdewilligen & Waller, 2018), which in turn results in diminishing work complexity, improving quality and buildability, and enhancing fitness-for-purpose (Yoon et al., 2011). Accordingly, such benefits motivate parties in collaboration to fulfil their obligations with good-faith and in a reliable way (Nooteboom, 2007), and additionally, to refrain from opportunistic behaviour and build long term trust. Huxham and Vangen (2013) further confirm that trust is a critical component of collaboration depending on shared ethics and prior experience between participants, and a time frame to build trust is unwarranted. Ostrom (1998) emphasises that the willingness of collaborative parties to commit to common interest take the collaborative parties away from the conditional " I will if you will" reciprocity into a new contracting mechanism needed for the collaboration to flourish.

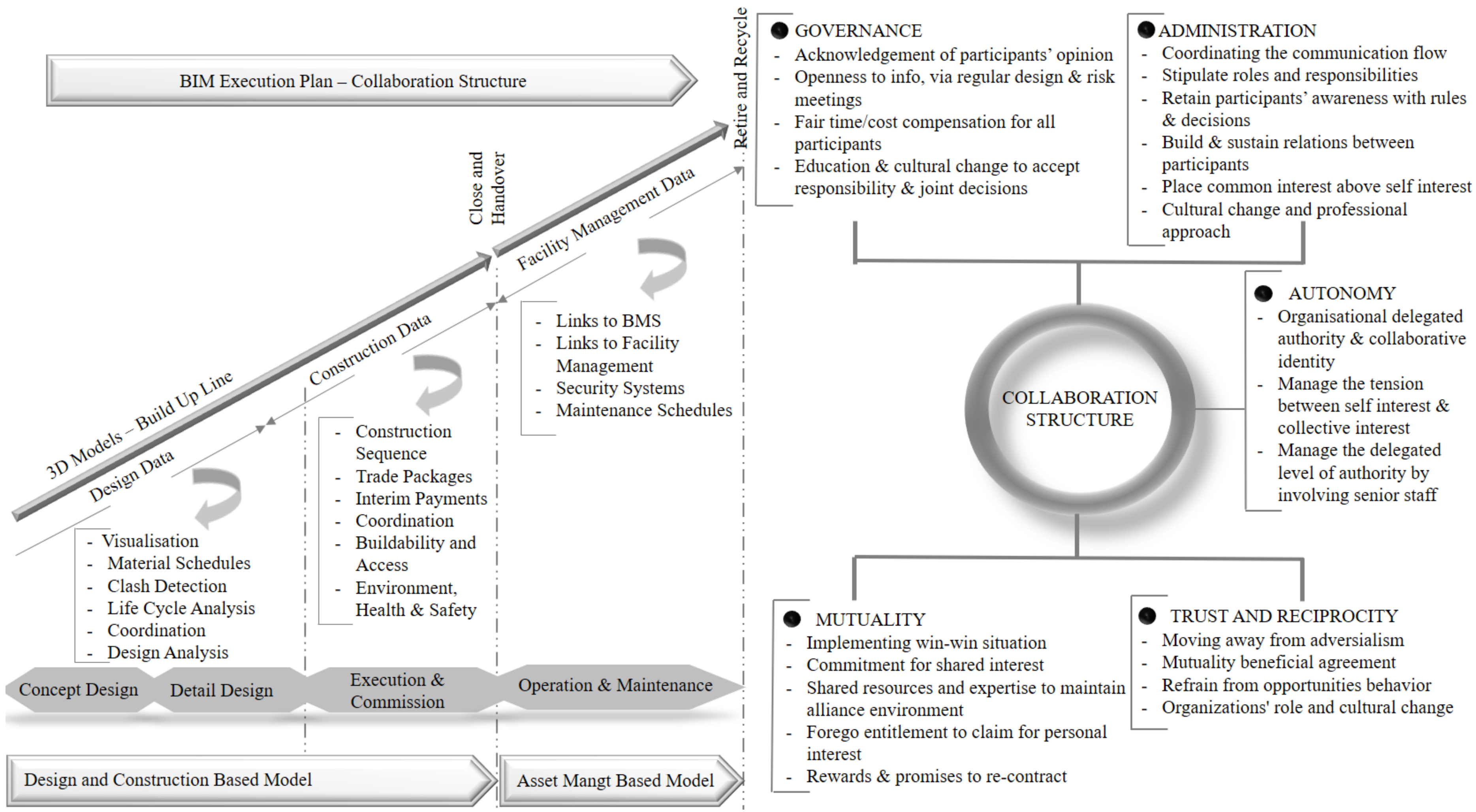


Figure 2. 5 Collaboration dimensions

2.6 Conflict and Collaboration

Collaboration facilitates resolution of challenges and creation of real value. However, it requires all parties to be passionate about the common objectives. Predictability of conflict to occur and the concept that conflict can be a chance for positive growth form part of this passion. Understanding such concept by all parties enable constructive discourse leading to creative and lasting objectives greater than their anticipation. The question that how conflict can be taken to transform into a leasing relationship is initiated by (Gray, 1989) who states: “Collaboration operates on the premise that the assumptions disputants have about the other side and about the nature of the issues themselves are worth testing” (p.13)

Scarcity of resources is a main motive for collaboration to form to leverage capabilities and assets, especially when such resources are associated with complex issue (O'Toole Jr, 1997). Collaborators come together with different resources that all of them need to achieve shared vision (Thomson, 2003; Thomson & Perry, 2006). However, shared vision alone do not ensure constant agreement between parties unless it combined with an interest to resolve conflict. Therefore, parties need to face the obstacles as they unfold for their collaboration to succeed. Davoli and Fine (2004) states: “the sincere practice of collaboration dictates that all parties involved will take part in the decision making.” (p.268)

2.6.1 Understanding Conflict

Dean and Kim (2004) refer to conflict as “a perceived divergence of interest” (p.15), where interests are translated to aspirations, and incompatible aspirations lead to conflict to exist. Gray (1989) argues that deciding on how to carry out the vision or in the implementation of agreements are two possible scenarios for conflicts to arise between parties.

Dean and Kim (2004) clarify the conditions that encourage conflict and state: “When communities lack normative consensus, some community members will have aspirations that are incompatible with those of others, and conflict will be common... Low conflict communities have particularly clear norms governing those interpersonal relationships that are most prone to conflict, such as authority and status relationships.” (pp.26-27)

It is argued that role differentiation and hierarchical differentiation facilitate the ”who does what” labour division, and hence efficient interactions among interdependent organisational members (Halevy et al., 2011). In addition, hierarchy also offers expressively prominent and stable solutions to shared problems, which contributes to the formation of governance structure (Meyerson et al., 1996). However, stakeholders still need a structure to form. A study conducted by Takahashi and Smutny (2002) shows that inflexibility to meet the changing needs of collaborative work compromises collaboration and hence cause gradual departure of relationships between stakeholders. Collaboration success is dependent on the way stakeholders frame and reframe issues and form interactions with each other to make sense of the conflict. Diverse framing makes it hard for stakeholders to achieve agreeable solutions, which in turn causes collaboration to split.

2.6.2 Communication and Culture

Direct interaction between stakeholders promotes constructive change that fosters cooperative behaviour over competition (Marlowe et al., 2011). Although communication and culture are inseparable, communication overcomes culture differences (Leavitt, 2010). Emotion and conflict are connected in a sense that conflict is driven by emotion; however, individuals understand emotion via means of communication (Eadie & Nelson, 2001).

McNamara (2010) clarify collaboration requirements and states: “Collaboration typically requires great levels of commitments and time as stakeholders with a particular arrangement frequently interact to develop shared norms, rules, and processes used to make collective decisions impacting mutual interests” (p.129). Findings from a case study on Virginia Coastal Zone Management Program show that in the absence of a control structure, parties were not able to decide on how and to what extent they would work together to implement the program. However, parties successfully used their relationships to create “vibrant collaborative interactions” (McNamara, 2010, p. 145). Therefore, culture has a role in the collaborative process and it is important to understand how each stakeholder view the cultural difference.

Creativity results out of conflict, which contributes to the creative potential of collaboration. According to Takahashi and Smutny (2002) “Conditions leading to the formation of collaborations may sow the seeds of their demise in the relative short term" (p.166), which in turn suggests that conflict and associated conditions need to be embraced and integrated into a start-up process. Parties in a collaborative framework need to frame the conflict by presenting it in its original state and reframe it in a different thought that is more likely to support resolution efforts (Mayer, 2004). Reframing the conflict allows emotions to successfully communicated between parties, and hence conflict transformation. Parties need to place aside their cultures so each party moves away from "parallel play" where conflict is looked at from a personal perspective to "interdisciplinary work" (Kalishman et al., 2012).

2.6.3 Summary

Collaboration is a means for organisations to join together and create real value (Morris & Miller-Stevens, 2015). However, organisations, when coming together, will face differences among their individuals. Such differences could stifle the collaborative efforts (Lederach, 2015). Therefore each party needs to direct their culture and resultant communication style towards an overarching goal of cohesive environment where conflict is dealt with as a means to goal achievement rather than the enemy.

Although conflicts if carefully and appropriately treated can facilitate cohesive and collaborative environment that is sustainable to solve all challenges, successfully achieving the required objectives might not be the case for all organisations. Therefore a dispute resolution framework is required to assist organisations navigate through conflicts as they unfold and hence successful collaborative efforts (Vaaland, 2004).

2.7 Inter and Intra Organisation Systems

Any extended enterprise must transfer information in terms of processes, procedures and practices throughout the supply chain to operate effectively (Barson et al., 2000). Various factors facilitated the shift towards cross-boundary information sharing, such as technology evolution, and government policy to improve efficiency and reduce waste (Yang & Maxwell, 2011).

Davenport et al. (1998) define knowledge as "information combined with experience, context, interpretation and reflection" (p.43). This definition confirms that the receiver of information is liable to apply their experience to properly interpret such information into implicit knowledge in the intended context. Therefore collaboration between both parties is the primary issue for knowledge management process. However, knowledge sharing is faced with barriers and difficulties, which can jeopardise the capture and translation of information into meaningful specifications.

2.7.1 Intra-Organisational Information Sharing

Information is viewed as a form of property; therefore within the organisational context, information sharing can be more challenging (Constant et al., 1994). According to the literature, limited access to and information sharing compromise organisations' capability to develop integrated solutions when addressing problems (Wheatley, 2011), and makes information flow in organisation groups strictly controlled (Cress et al., 2006). The intra-organisational information sharing is influenced by several factors which are deemed to have complex relationships. Such factors like organisation norms and culture in addition to trust, incentives and adopted technology. Initiatives of inter-group information exchange and collaboration can be hindered by a structure that is centralized in higher management levels (Kim & Lee, 2006).

Tolbert and Hall (2015) define formalisation as formal rules, procedures and regulations of an organisation and argue that informal rules facilitate information sharing and knowledge more than formal systems. Lateral and informal systems such teamwork are not defined by regulation, hence lead to greater flexibility and openness in the interaction between organisational members (Willem & Buelens, 2007)

Organisational culture, values and norms significantly influence members' decisions and perceptions regarding sharing information (Jian & Jeffres, 2006). Organisational culture can positively influence information sharing if it emphasises fairness, affiliation and innovation (Chen et al., 2012). A culture that focuses on mutual interests, solidarity and shared objectives motivates stronger beliefs to organisational information ownership as opposed to individual and hence tend to share information (Jarvenpaa & Staples, 2001).

Information technology is another important factor that influence information sharing and knowledge (Barua et al., 2007). However, information technology need to be easy and efficient to use to improve information sharing. Also, researchers point out that explicit information is easier to articulate and share than tacit experience-based information (Stenmark, 2002).

2.7.2 Inter-Organisational Information Sharing

The importance of cross-boundary information sharing is widely recognised in the literature (Pardo et al., 2004; Schooley & Horan, 2007; Yang & Wu, 2014; Zheng et al., 2009) to raise consciousness Marshall and Bly (2004), and hence provide better and innovative services. However, as indicated by Wilson (2010), information sharing is a complex phenomenon, which is influenced by various factors from different perspectives (Landsbergen Jr & Wolken Jr, 2001).

From the technological perspective, the advancement of information technology enhance the efficiency and effectiveness of inter-organizational collaboration (Zhang & Dawes, 2006). Different organisations have various types of hardware and software in their information systems, and it is a challenge to integrate heterogeneous information systems of different platforms, data standards, schemas and qualities (Gil-Garcia et al., 2009). Furthermore, security and confidentiality concerns entail a requirement to design a system that can handle authentication and authorisation for any shared information (Chau et al., 2001).

From an organisational perspective, (Gil-Garcia et al., 2007) point out that complex interactions between participating organisations is encountered when sharing information and knowledge because of their different origins, values, and cultures. Trust is another important factor, on which inter-organizational information-sharing relationships rely heavily (Gil-Garcia et al., 2010). Counterintuitive relation between trust and information sharing is observed in a case study on oil rigs conducted by Hassan and Allen (2012). Researchers assert that trust enhances communication, and subsequently promote efficient information sharing (Barua et al., 2007; Choi et al., 2008; Wu et al., 2007). However, the concern of information providers about losing their independence and the possibility to abuse the information by other organisations impede the trust in information sharing (Li & Zhang, 2005). Therefore clearly stipulated roles and responsibilities, respect for autonomy and appropriate exercise of authority lead to build trust between participating organisations (Yang & Maxwell, 2011). Leadership is emphasised by Akbulut et al. (2009) that can be utilised as a force to promote cross-boundary coordination between organisations.

From political and policy perspective, lack of legislation and policy to protect the privacy and confidentiality have a strong influence on the sharing of information and knowledge across organisations, especially for organisations in the public sector (Zhang & Dawes, 2006). Laws and regulations that prohibit government agencies from sharing sensitive and regulated information in domains such as public safety and national security are barriers obstruct the cross-boundary information exchange.

2.7.3 Summary

Based on the literature review, several factors at the interpersonal, intra-organizational, and inter-organizational levels are identified as important to successful information sharing. At the interpersonal level, socialisation is critical as both an influential factor and a process that facilitate the sharing of information, in the form of explicit knowledge and tacit knowledge, between individuals. However, the information-sharing behaviours become more complicated when individuals are within the contexts of intra-organization and inter-organization (Table 2.3)

Table 2. 3 Collaboration barriers

Factor	Barrier	Description
Cross-category barriers	Resources	Organisations need to data transfer mechanism skills and time to implement and develop the accumulated knowledge
	Rewards	Organizations need to demonstrate that sharing knowledge result in an immediate gain of less work, and easier tasks. The reward and its mechanism need to be managed
	Culture	The support for sharing information need to be embedded within the organization policy
Technology barriers	Legacy systems	Achieving true interoperability between various system in different organisations is a challenge
Organisation barriers	Knowledge transfer management	Cost to manage collaboration is substantial when dealing with incapable parties
	Intellectual property and exclusive knowledge	The risk to compromise organization's exclusive knowledge impede sharing information
	Geographical separation	Across boundaries results in different cultures, legislative system and linguistic environment
People barriers	Resistance to change	Organisations desire to protect their interest. Lack of supporting contribution from top management. Established organisations tend to control smaller ones.
	Self interest	Possibility that competitors to access the shared information and benefit from any sensitive information deal and share knowledge
	Trust	Lack of trust between collaborators hinders information sharing
	Exploitation	Lack of common interest when sharing knowledge becomes conditional to the benefit in return
	Contamination	High end market organisations hesitate to deal and share knowledge with the lower end market organisations.

Sources: (Beecham & Cordey-Hayes, 1998; Doz, 1987; Farr & Fischer, 1992; Lakemond, 1999; Nonaka & Takeuchi, 2007; Ragatz et al., 1997; Scarbrough et al., 1999; Schwartz, 1999; Tabrizi & Walleigh, 1997; Trott et al., 1995)

The lack of integration between multidisciplinary engineering firms in the construction industry (Briscoe & Dainty, 2005) adds further complexity to information sharing. Therefore the innovative solution of building information modelling (BIM) has been adopted to facilitate opportunities for knowledge transfer and hence inter-organizational integration (Bryde et al., 2013; Dossick & Neff, 2009).

Miettinen and Paavola (2014) cited in (Papadonikolaki & Wamelink, 2017) define BIM as "multifunctional set of instrumentalities for specific purposes that will increasingly be integrated." (p.86). Therefore, BIM is a domain for information technology systems to exchange, control and manage the flow of information intra and inter organizationally.

Aiming to improve the traditional fragmented project-based procurement, BIM is deployed to achieve integration. Evidence confirming that BIM enhances the coordination of various multidisciplinary engineering works under intensive communications between project parties is discussed by various authors (Ahn et al., 2015; Dossick & Neff, 2009; Wang & Leite, 2014).

2.8 Collaboration and Technology

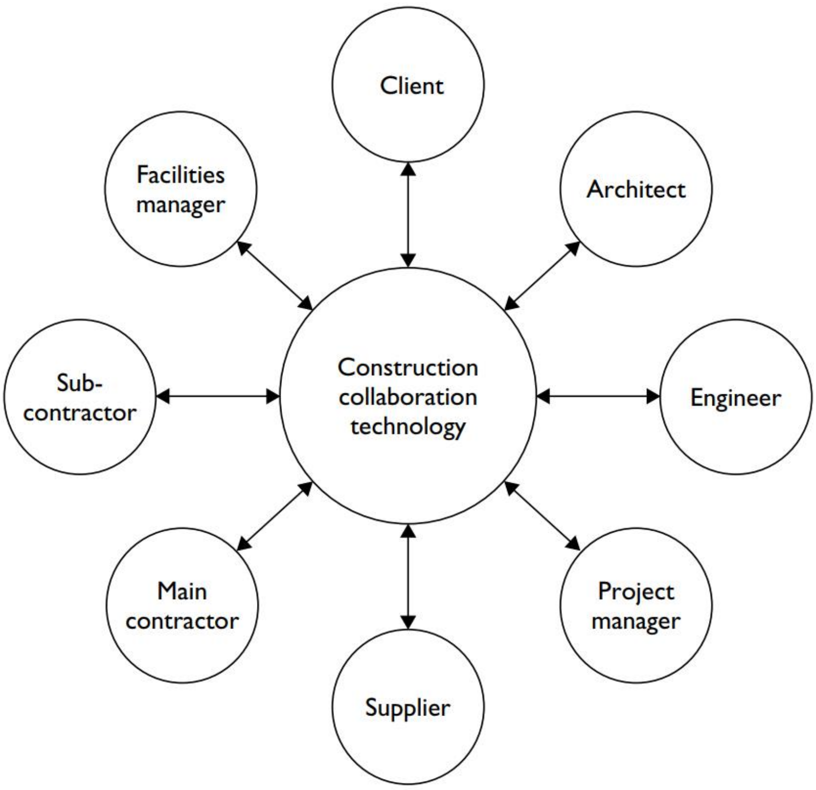
Project parties employ different software and/or hardware to facilitate collaboration. The term collaboration technology often refers to various provisions such as enterprise portals, web and video conference applications, online meeting applications, file transfer and data sharing applications, real-time instant communication. Depending on the working environment, collaboration may require real-time or synchronous interactions between parties. In some other instances, collaboration is undertaken via asynchronous interaction when time delays incurred (Brown et al., 2010).

Applications for synchronous collaboration could face-to-face communication when participants are not available within the same area, while asynchronous collaboration involves reviewing a design package produced by one party by another at different timing. Therefore technology considers to be an enabler allows collaboration to take place between various parties.

Wilkinson (2005) defines collaboration technology that covers the principal features of information sharing between project parties and state as follows:

"A combination of technologies that together create a single shared interface between multiple interested individuals (people), enabling them to participate in creative processes in which they can openly share their collective skills, expertise, understanding and knowledge (information), and thereby jointly deliver the best solution that meets their common goal(s), while simultaneously creating an auditable electronic record of the people, processes and information employed in the delivery of the solution(s)" (P.5)

Implementing a private and securely managed collaboration platform to share and make available project related information to all authorised participants is best illustrated in the Figure 2.6



Adapted from: (Wilkinson, 2005)

Figure 2. 6 Project team communications using construction collaboration technologies

2.8.1 Accelerating Change and Rethinking Construction

Egan (2002) discuss the change in the construction industry and associated challenge to provide clients with maximum value. The discussion echoed the need for deploying integrated teams and supply chains using an integrated technology approach. Such integration ensures an equitable contribution of team members with shared risk and reward attitude. Integrated technology approach facilitates a system for almost immediate exchange of information, hence enable the update of drawings and data by all design service providers.

The emerging importance of technology makes it the catalyst for communication platforms and protocols. The implementation of collaborative and integrated methods in a very price-sensitive industry becomes imperative. Technology allows to mitigate undesirable rework, and hence reduce costs and waste, enhance productivity and expedite progress. The capability to reuse digital documents for different purposes, search by title, and manage in customised work environment and to transfer across various geographic boundaries exceed the functionality and usability features of previous paper-based documents (Steimle et al., 2009). The cost of rework is always traced back to poor-coordination that is resulted from inconsistent, inaccurate and delayed information (Love et al., 2018). The fact that construction industry being information-dependent, collaboration is the proposition that organisations need to ensure sharing accurate information promptly.

Collaboration technology again represents a logical and obvious answer for different types of contact forms such as Private finance initiative (RFI) and Public-Private Partnership (PPP) (Love et al., 2015). These types facilitate a stimulus of combining finance, design, build and operation activities. The client in such projects is often a “special purpose vehicle” or known as consortium that includes in addition to the owner, designers and contractors, another organisations liable for raising funds and for operating and maintaining the final product for a period between 25-30 years. Such type of project procurement entails a huge amount of information and documentation to share and compile for a successful submission of a bid. Therefore, collaboration technology is the solution for the project team to utilise. Central repository of data accessible by all authorised parties satisfy the demand for efficient construction and management of the facility.

Collaboration technology is the combination of several technologies to provide a powerful communication platform for the project team. Software is a critical part of the technology that affects how quickly for team members to become proficient at using the system.

2.8.2 Technology Features and Functionality

Researchers emphasise the importance of technology to facilitate collaboration. A package of hardware and software that supports better communication among participated organisations, and supports an efficient information-processing, and hence improve decision-making (Adornes & Muniz, 2019). Several studies have examined the adoption of collaboration technologies (Bajwa et al., 2005; Bajwa et al., 2008; Dennis et al., 2001; Desanctis & Gallupe, 1987; Lou et al., 2005; Pervan et al., 2005; Vessey et al., 2002), which perceive that effectiveness and efficiency of performance of participants are influenced by technology. However, the adoption of technology is influenced by four main characteristics and as follows:

- Technology Characteristics

Vajjhala (2015) clarifies that the emergence of technological advances have enabled new opportunities and collaborations for participants to share information and work together. David et al. (2016) argue that collaborative technology help stakeholders to execute their work activities adequately. The technological evolution results in more reliable communication and interaction among participants (Belk, 2014). Accordingly, technology is seen as a means to foster collective construction or the concept of "crowdsourcing" as described by Brabham (2013) "a history of cooperation, aggregation, teamwork, consensus and creativity." (p.26)

- Individual and Group Characteristics

Successful use of collaboration technology is potentially dependent on the individuals and groups due to the different corresponding needs (Dennis et al., 1988). In this context, researchers such as Brown et al. (2010) and Sarker and Valacich (2010) clarify that social influence is essential as all forms of collaborative technology is designed to be utilised among group members not individually. Venkatesh et al. (2003) define social influence as "the degree to which an individual perceives that important others believe he or she should not use the new system"

(P.451). Therefore individual's perception that the new technology would enhance their performance influence the attitude and behavioural intention toward using the technology. Perceived ease of use and usefulness are defined by Davis Jr (1986) "the degree to which an individual believes that using a particular system would be free of physical and mental efforts" (p.26).

The above corresponds with the four external variables identified by Lee et al. (2003) that influence technology adoption; self-efficacy, trust, risk, anxiety, innovativeness, and security and privacy.

- Task Characteristics

Researchers recognise task as an important factor that influence performance (Dennis et al., 1988; Dennis et al., 2001; Desanctis & Gallupe, 1987; Fjermestad & Hiltz, 1998; Jerry Fjermestad, 2000). Collaborative decision task where group members need to understand each other and to achieve consensus require more interaction and hence social presence is of great value (Robert & Dennis, 2005). Therefore technologies that endorse synchronicity is best to facilitate group agreement.

2.9 Conclusion

Dependent on circumstances and research questions, collaboration literature relies either on frameworks or theories and inter-organizational arrays. However, there are limitations and strengths associated with each approach. The complexity of collective work is emphasised through collaboration frameworks where the dynamic, iterative and adaptive nature of collaboration are stressed. In addition to that, the relationship between collaboration input, process and output variables is conjectured often at different levels of analysis. However, the applicability of frameworks to organisational levels from leadership level to implementation levels is ambiguous. Hence, frameworks have less utility in specifying the level of applicability in organisational terms.

Theories, on the other side, depict standard forms of interaction between collaboration variables and assume the existence of repeatable characteristics of collaboration. In contrast to frameworks, the level of applicability in organisational terms is clearly specified with context built into the construction of theory. The literature reveals the lack of generalizability of collaboration frameworks. Theories demonstrate that unless in a given context and environment, the general forms of interactions are rarely meaningful.

Collaboration is always seen through a lens of context, and the lens in this research is Building Information Modelling. This research introduces a conceptual framework, where participation in a collaborative arrangement is based on a mandate requiring interaction. The main dimensions of the framework are more aligned with collaborative properties derived from literature and semi-structured interviews conducted with industry experts. Variables associated with the main dimensions are tested against court judgements to confirm the legitimacy and applicability in the construction industry.

The proposed framework explores different types of interactions in multi-organizational setting and facilitates better understanding of collaboration elements that contribute to the success of interaction. Therefore it is important from theoretical and practical standpoints to scholars and practitioners respectively and enables a strong foundation for further in-depth examination to respond to developing circumstances.

CHAPTER 3 BUILDING INFORMATION MODELLING

3.1 Chapter Introduction

Building information modelling (BIM) is reshaping the way construction projects are being delivered. Synergistic design and construction teams with efficient communication able to produce, share and maintain a high degree of consistent information along the project life cycle.

BIM has become a favourite topic in the construction industry (Succar, 2010b) with widely recognised benefits (He, 2010). BIM is regarded as information technology-based workflows, where communication and integration are emphasised, and its domain continues to expand (Succar, 2010a). Demian and Walters (2014) clarify that the technology and process established by BIM have enabled the representation of buildings and infrastructure throughout their lifecycle. Construction errors and associated reworks can be dramatically decreased through automated assembly and enhanced processed, which, in turn, improve quality and efficiency (Liu et al., 2015).

Group (2010) argue that in addition to the practical solution that BIM provides respect to sustainable building design, it promotes collaborative working practices, and enhances communication between participants. However, researchers assert that seamless integration of BIM into the daily working processes is one of the main challenges to implement BIM (Kekana et al., 2014; Li et al., 2017).

This chapter presents a general categorisation of typical construction claims with an overview of some of the types of issues and damages. An outline of BIM tools, workflows, and processes for both designers and contractors is also presented. Together these, provided a view on to the current landscape of construction disputes, and a lens of new BIM tools and processes which would alter the shape of that landscape. The intent of this chapter is to explore BIM in the context of legal issues and consider notions of claims through examples of specific definitions and relevant clauses from several contract documents prepared by AIA and ConsensusDocs and other contract forms. Samples of published cases and court decisions regarding standard of care and workmanlike performance are also used.

3.2 Legal Uncertainties of BIM

Traditionally, contractors have relied on paper-based documentation produced by projects' design team to prepare tenders and to carry out construction. However, there is a proclivity for such documentations as they are often incomplete and contain clashes/contradictions, errors and omissions. Construction claims differ in content and vary from technical issues to standard of care, albeit all related to monetary compensation. However, it is important to appreciate all terms and conditions, whether expressly or impliedly stipulated in the contract so that different understanding about compensation entitlements are not developed (Semple et al., 1994).

The context of legal precedence is such that decided cases provide guides on courts' expectations regarding the position of the law around elements of disputes and the evidence put forward by disputants (Uff, 2013). The fact that few BIM-specific cases have been reported makes it difficult to understand the impact of technological evolutions on traditional processes. There being no contract instruments to drive BIM other than traditional instruments, and these instruments have not shown considerable capacity to attenuate or help avoid crisis. However, the burden of proof that construction under BIM is still as controversial as traditional contracts cannot be removed.

BIM provides platforms where parties create and share information in a digital format collaboratively at a high level of accuracy and efficiency. The collaborative structure entails parties to work within data-rich models, which triggers the requirement to incorporate unstated liabilities. For example, liability for intellectual property should be assumed when a multidisciplinary model is shared amongst many parties.

Many other benefits have been attributed to BIM, however technological interoperability and associated legal gaps are significant drawbacks hindering its deployment (Arensman & Ozbek, 2012). BIM demands that project teams collaborate seamlessly; however, the tenant of traditional contract forms do not support this. Studies have shown that BIM projects are not likely to succeed unless contractual provisions are well defined to govern participants' obligations under a collaborative working environment.

3.2.1 Responsible Control and Contractual Disputes

The existing legal structure and procurement methods lack provisions to accommodate the integrated design approach (Gibbs et al., 2015). Despite the significant benefits that can materialise from implementing BIM, existing lump sum and pre-agreed schedule of rates, contracts are unable to accommodate the required collaboration (Ibbs & Ashley, 1987). Both approaches require design to be completed before construction based on separate agreements where parties are liable for different responsibilities. Therefore suffice to say that each party acts in the contexts of its corporate objectives and particular tolerance for risks. Accordingly, identification and allowance for risks being assumed under such contractual arrangements will not serve the purpose in collaboration work environment.

In addition, the collaborative nature of BIM and its objective of inseparable responsibilities conflict with the single point of responsibility stipulated by law and Code of Design Management (Joyce, 2007). The Code obligates architects to coordinate design and, contractors to coordinate construction work. Existing international contractual frameworks such as Federation Internationale des Ingenieurs-Conseils (FIDIC), Joint Contracts Tribunal (JCT) and Australian Standards (AS 2124, and AS 4000) often contain generic provisions for collaboration; yet place different set of responsibilities on each contracting party.

The Rules of Conduct as stipulated by the National Council of Architectural Registration Board assumes the "Responsible Control" as "An architect may sign and seal technical submissions only if the technical submissions were: (i) prepared by the architect; (ii) prepared by persons under the architect's responsible control". However, courts address "responsible control" differently. For example, in *Wynner vs. Buxton (1979)*, the Court of Appeal, California, held that an architect liability for civil engineering plans does not include all other engineering disciplines. According to Dougherty (2015), BIM as a highly collaborative endeavour departs from the legal assumption of "responsible control", which in turn concurs with the legal approach.

Effective communication and information sharing among team members are prerequisites to manage conflicts (Diekmann & Girard, 1995). Poor communication is among other shortfalls engender claims and disputes in construction (Love et al., 2010). The inclusion of disputes resolution mechanisms facilitates a less adversarial environment; however, communication remains a vital aspect in all contract forms (Chan 2003; Martin & Thompson 2011). Although implementing BIM, as argued by Olatunji (2015) reduces uncertainty and controls conflicts between project parties, communication is crucial for BIM to achieve its objectives. A case study reported by Dougherty (2015) shows that an architect and MEP consultant used BIM to coordinate high-level services but failed to communicate certain sequencing requirements to the contractor. Consequently, the contractor, following 70% of work completion, ran out of space and hence sued the owner for damage who in turn sued the architect and MEP consultant.

BIM-related legal concerns are associated with contract or technical issues and these can be looked at in the following contexts:

- Scope of Work

The essential information of any project is normally identified during the initiation phase; therefore an early implementation of BIM enhances visualisation, increase coordination of design documents, and retrieval of information for further project's life cycle phases (Love et al., 2015). Compliance with building codes and standards and coordination between drawings result in voluminous information of different formats that contracting parties need to maintain and administer throughout the work.

In a design and build contract, the owner engaged an architect for the design and construction of a sports complex that encompasses skating rink and five squash courts. A structural engineer was engaged by the architect directly for the design and supervision of the structural works. No contract between the owner and the structural engineer exist. During construction, the contractor experienced failures of some lifting pins and other structural members. The contractor sought independent engineering advice, which confirmed that the design was structurally unsafe and inadequate. The owner sued the architect for breach of contract and the engineer for negligence in his design. Court held the engineer to be negligent in his design. The court attributed the judgment to the fact that the design departed substantially from the relevant engineering codes of practice and that this was prima facie evidence of a defective design (*Bevan Investments Ltd v. Blackhall and Struthers, 1973*).

In a traditional lump sum contract, the impractical nature of the design doesn't entitle the contractor to claim for extra cost that might be incurred to achieve the desired objective (MacRoberts, 2008). In the case of *Williams vs. Fitzmaurice* (1858), the contractor's claim for additional cost to do the flooring was rejected by the court. The judgment was based on the fact that despite the flooring was not specifically itemised; it is considered of necessity to deliver a habitable house; therefore contractor was to allow for the flooring material.

In design bid build contract, the design tasks are separated from construction. Owner normally contract an architect via a separate contract to provide the contractor with design drawings. Such design is assumed to be fit-for-purpose and defects free. Courts in various cases have decided that Contractor's liability is to carry out the works doesn't extend to scrutinise the design and confirm its adequacy (*Co-operative Insurance Society Limited vs. Henry Boot Scotland Limited, 2003; Aurum Investment vs. Avonforce (2001); Edward Lindenberg vs. Joe Canning and Others, 1992*).

From common law perspective, the contractor is liable to execute the works skillfully. Such liability entails obligations to warn for design defects and danger that any other competent contractor would perceive. Courts in that context, take the view that when owners rely on the contractor's skills, contractor ought to warn for any apparent unsatisfactory details that could result in an adverse consequences (*Brunswick Construction Ltd vs. Nowlan and Others (1974); Equitable Debenture Assets Corporation Ltd. vs. William Moss Group Ltd. And Others (1993)*).

In the case *Plant Construction vs. Clive Adams Associates (first defendant) and JMH Construction (second defendant)* (2000), the inadequate temporary supporting works of roof trusses caused major roof collapse after heavy rain. Court held that the contractor was liable to carry out the works with skill and care and that they ought to be aware of the obvious risk of the inadequate propping. Such judgments place an implied liability on the contractor to apply their competency and not to proceed with the construction of unworkable design.

The integrated and collaborative work procedures in BIM-enabled projects result in risk mitigation throughout the project life cycle. With the ability to spatially coordinate digitally in three-dimensional space, BIM enables the architect and other engineering discipline consultants to produce multiple appropriately segregated Design models using their specific software tools. The AIA E-series (E203- 2013) documents designate the architect as the default project participant responsible for the management of the models and to make available for use by contractors. The Associated General Contractors (AGC - 2005) acknowledges the benefit to construction teams of receiving constituent Design-BIMs. The AIA and ConsensusDocs provide means of facilitating exchange and establishing rules of Design-BIMs and Construction-BIMs development, reliance and authorised use between design and construction teams. Such an arrangement directly supports the delivery of better-coordinated contract documents.

Similar processes for construction teams exist. Contractors and subcontractors develop and compile various Construction-BIMs of their scope of work to facilitate coordination, sequencing, scheduling, and as-built models. Contractors utilising BIM tools and processes can better mitigate risk in project delivery.

- Commencement, Delays and Legal Implications

The construction law obligates the owner not to deprive the contractor from performing their duties in a regular manner (*London Borough of Merton vs. Stanley Hugh Leach Ltd., 1985*). Such obligation includes giving contractor site possession and access to commence the works. Any provision for dividing the site into sections with different completion and handover dates need to be stipulated in the contract.

A construction contract required the owner to excavate the site to a specified level and to give to the contractor possession of the site, duly excavated, not later a specified date. The owner failed to excavate the site and didn’t give possession to the contractor by the specified date. The owner also engaged a third party to carry out the fabrication of steelwork, notwithstanding a provision in the contract states that such work was to be performed by the contractor. The contractor formally advised the owner that the contract was at an end. The High Court of Australia held that the owner by his conduct had evinced an intention no longer to be bound by the contract so that the contractor was justified in acting as he did (*Carr v J A Berriman Pty Ltd, 1953*).

Achieving completion date is critical to prevent liquidated damages. However, delay in work progress prior to achieving the contractual completion date doesn’t entitle the owner to claim for damages. In the case of *Greater London Council vs. The Cleavland Bridge and Engineering Co. Ltd and Another* (1986), the court of appeal held that the contractor’s express obligations were to complete the works by the due dates, thereby declined the owner’s request to determine the contract.

Any instruction from the owner to speed up the work to achieve an earlier completion than originally what originally agreed on, would force the contractor to deploy extra site personnel and possible overtime. Consequently entitle the contractor for acceleration claim to compensate for the extra costs. However, in a contractual context, there are what contracts usually define as excusable delays that contractor encounter during construction and fall beyond their control. Such delays entitle the contractor to claim for time extension, which in turn subject to approving such claim by the owner delays the completion date. ConsensusDocs 200 Standard Agreement and General Conditions Between Owner and Constructor (Article 6.3.1) states the events that cause excusable delays such as owner’s driven changes, design omission by the owner, drawings discrepancy, instructing changes in the construction sequence and similar events.

- Disruption and Associated Damages

The society of Construction Law refers to the disruption as precluding the contractor from carrying out the scope of work as originally intended. Thus inefficient utilisation of plants and manpower, which in turn if so is caused by the owner gives rise to a claim for compensation.

In the case of *H and S Alexander v Housing Commission* (1985), the owner told the contractor that he would be given possession of the site on 11 July 1979. Possession was not given in time for the contractor to commence operations on the necessary date, viz 25 July 1979. On 28 July 1979, permission to start was given but it was not communicated until 30 July. Possession of the rest of the site was not given until 1 October 1979. The judge held that the owner’s behaviour went beyond what was contemplated by the contracting parties, therefore amount to disruption of work and found that it was a breach of contract such as to set the time at large.

Implementing BIM entails all parties to hold in addition to the regular meetings, frequent coordination workshops to discuss progress and other issues, therefore disruption in the form of preventing contractor or any other party from accessing site or commencing work shall result in substantial loss that need to be compensated.

3.2.2 Standard of Care and Professional Negligence Claims

Except when clients' requirements are practically not feasible [e.g. a consensus ad idem situation], BIM collaborators are obligated to render professional services with reasonable judgment to prevent injury, loss or damage to own client's and "other property" [*Greaves & Co (Contractors) Ltd vs Baynham Meikle & Partners, 1975 and, Payne vs John Setchell Ltd, 2001*]. In addition, project teams are required to avoid causing foreseeable damage by negligent acts or omission (*see Junior Books Ltd vs Veitchi Co Ltd, 1983*). Such requirement is best achieved when members of the project team can collaborate seamlessly. Furthermore, such a duty of care includes avoiding economic loss when there is sufficient proximity between parties and direct causal relationship between negligence claims and consequent damages (*Glasgow Airport vs Kirkman & Bradford, 2007; and Earl Terrace Properties Ltd vs Nilsson Design Ltd, 2004*).

The contractual relationship governs both the existence of a duty in tort and its extent. That does not mean there cannot be concurrent liability in all the circumstances (*Australian Mutual Provident Society v Dowell Australia ltd, 1988; Tai Hing Cotton Mill Ltd v Liu Chong Hing Bank Ltd, 1986*). The Supreme Court of Queensland in the case of *Robt Jones (363 Adelaide Street) Pty Ltd v First Abbott Corp Pty Ltd* (1998) concluded that the nature of the contractual relationships entered into by the contracting parties precluded a relationship between them such as to give rise to a duty of care in negligence.

Contractual risk is voluntary and for appropriate consideration. Apportionment for contributory negligence is, on the other hand, a matter for tortious liability imposed by the parties' relationship, rather than their voluntary contract (*Astley v Austrust*

Ltd, 1999). In the case of (*Yuen Kun Yeu v Attorney-General (Hong Kong), 1987*), the Privy Council held that a close and direct relationship between the parties had to be established before liability in tort for negligence and economic loss could be established. In deciding that, regard had to be had to the reasonable contemplation of harm being caused. For example, the builder of a 22 storey block of units in St Kilda Road should have sufficient contemplation of purchasers for there to be proximity. Yet, such purchasers will generally have difficulty proving reliance upon the builder (*David Opat v National Mutual Life Association of Australia Ltd and Costain (Aust) Ltd, 1993*). Under sufficiently special circumstances, there can be a cause of action for pure economic loss, even where the plaintiff cannot prove reliance but can prove sufficient proximity-except in respect of negligent misstatement (*Latrobe Valley Village Inc v CSR Ltd and Monier Ltd, 1990*). Such proximity must, to be sufficient, be constituted by evidence more than just the reasonable foreseeability of the type of damage or injury (*Wyong Shire Council v Shirt, 1980*).

There is much commercial common sense in construction contracts which adopt the philosophy of expressing the duty to alert, followed by the duty to give a direction. Commercial contracts, and especially long term ones, need such mechanisms to make such contracts work in the face of discrepancies and reasonably unforeseen shortcomings. Nevertheless, the obligation has to be expressed. A contractor forced into two years' overrun used the lack of due and proper information arguments. The court held that the implied terms were to be implied (*Perini Corp v Commonwealth, 1969*). Following on from the duty to co-operate, the contractor argued to the effect that the architect would provide him with coordinated, full and correct information concerning the works. The judge held that "coordinated" and "full" were going too far and should be deleted from the term to be implied. Correctness was a question of degree, but the judge did hold that the contractor was not under an obligation to check the drawings to see whether there were any discrepancies or divergences (*Stanley Hugh Leach Ltd v London Borough of Merton, 1985*)

In comparatively recent years, the Supreme Court of Florida has held that an architect was prima facie liable to the contractor for his negligent preparation of contract documentation (*Moyer v Graham, 1973*). Similarly, although the contractor had assumed responsibility under the construction contract for keeping his excavation free of flooding, he succeeded in a claim for negligence against the consultant engineers for their inadequate contract documentation whereby dykes forming part of the permanent works, in fact, turned out to be of insufficient height to contain the flooding from the adjoining river during heavy rain (*Schiltz v Cullen Schiltz, 1975*)

In a BIM project, sufficient proximity between contributors exists and in turn validates the assumption that all parties ought to be aware of design intents and clients' requirements regarding the final product. Such joint understanding gives rise to a duty of care to avoid causing damage and to permit recovery from losses resulting from the consequences of contractual breaches.

In addition to contract law, duty of care is further stipulated in tort unless tortious obligation is statute-barred or losses are pure economic loss (*Greater Nottingham Cooperative Society vs Cementation Piling & Foundations Ltd, 1988*). Obligations of the project team include avoiding foreseeable risks in carrying out the works. Designers are obligated to exercise due diligence and reasonable judgment, while contractors are obligated to carry out construction work as specified, including providing technical inputs to designs, and to warn clients about design defects and consequential risks (*Surrey Heath BC vs Lovell Construction Ltd, 1988; Lindenberg vs Canning, 1993*). As decided in the case of *Brown vs National Coal Board* (1962), unlike designers', contractors' obligations are not absolute, rather are limited to responsibilities that can be exercised reasonably in a contract (see *Morrison's Associated Companies Limited vs James Rome & Sons Limited, 1964*).

In *Aurum Investments Ltd vs Avonforce Ltd*. (2001), a subcontractor was contracted by the main contractor to underpin the flank wall in a way that will facilitate the construction of a basement. The underpinning subcontractor had completed the work and left the site. However, the main contractor excavated an area adjacent to the flank wall without providing adequate lateral support to the underpinned wall, which became unstable as a result of the excavation and collapsed later. The Court held that the duty of the underpinning subcontractor to warn does not include safety of work to be carried out by others in the future, which may compromise the safety of the underpinning work itself.

Arensman and Ozbek (2012) argue that contributors to federated BIM models are responsible for the data they provide and the service they render. However, unauthorised use of such information doesn't fall within their liability (Olatunji, 2014). Gero and Kannengiesser (2004) observed the difficulty often faced by designers in aided platforms. Designers are constrained within the strict boundaries of their authoring platforms; their ability to innovate and to communicate is limited only to the tools they use. One way to confront this challenge is for contributors to conform to specified guidelines while their systems are made open to receive and release information to tools and systems across different disciplinary boundaries.

BIM collaborators do co-create a product, the federated model. Success and liabilities in the development processes of the model are jointly shared amongst the contributors. However, parties often use disclaimers to avoid liability in the product they co-create (Dwight & Kate, 2007). The implication of this is that blames are shifted between parties but to no one in particular. For example, espoused benefits of BIM [e.g. clash detection, cost benefits, access to robust information, process simulation, and so on] often increase clients' expectations. Some clients do expect project teams to deliver BIM promises by default others consider deliverables as though they are outside the remit of traditional processes of project development (Pressman, 2007). When there are no systemic supports for this to happen automatically [e.g. in the nature of appropriate legal premise to drive target deliverables], it is only logical that stakeholders trade blames among themselves. Traditional professional liability hinders collaborative attitude and hence cause participants to provide their inputs separately. Professionals such as consultants, contractors, and suppliers have a duty of care to deliver fit-for-purpose product. Errors linked to a BIM model may jeopardise such duty of care as it deviates services from professional practice (Arensman & Ozbek, 2012). Such deviation collides with BIM as a collaborative platform in an electronic environment. Collaboration framework is needed where communication is fostered, decisions are taken jointly, and contract parties are interdependent.

3.2.3 Dissipation in the Integrity of Shared Information

Collaboration involves enforceable trust across multiple disciplines (Kvan, 2000). As Olatunji (2011) argues, information that flows across multiple disciplinary boundaries often do not retain the same level of integrity as original. Such assumption is due to information modelling seldomly targeting specific discipline (Amor et al., 2007a); and when information is shared, users [i.e. collaborators] choose what they needed [i.e. distort original information] to form a part of the product being co-created.

In the case of *RW Vaught Company vs. FD Rich Company* (1971), a subcontractor [Vaught] sued the main contractor [Rich] for an unpaid contract amount. Dispute had risen in a contract that was based on a computerised work schedule. Claimant [Vaught] was subcontracted to provide a heating plant. The plant was installed; however, the defendant [Rich] refused to pay for the completed work as completion was not achieved within the required timeframe. Defendant also claimed liquidated damages. However, delay was not established by the defendant as alleged. Early and late start dates for each work activity were retained in software program – in the same way as present day's commercial planning tools; both the claimant and the defendant could access these. Early start dates denoted potential commencement dates of corresponding activities; late start dates were absolute deadline to commence scheduled activities. Revised programs are made on actual commencement and completion dates as information became available. The Court found that the defendant amended contract schedule before consultation with subcontractors – the claimant included. The data used by the defendant were arbitrary. Impacted schedule, based on claimant's original contract, was disregarded erroneously by the defendant. The Court held that the erroneous data upon which the defendant's claim was made was a theoretical aspiration rather than practical contractual requirements. Defendant was ordered to pay the due amounts and for the extra work carried out by the claimant.

A contractual clause permits the main contractor to withhold moneys due to a subcontractor if the latter breaches the contract. The defendant has relied on the clause to withhold an amount due to the claimant. However, the defendant failed to convince the Court that the claimant agreed to revisions made to the schedule. The defendant also failed to substantiate the claim that noted damages resulted solely from claimant's alleged delay in achieving the completion date as agreed. Accordingly, the court decided in favour of the claimant and considered that the defendant's action as unlawful, and without a reasonable cause.

The case also went to the Appeal Court, where the Court reaffirmed the district court's decision. Rich's loss of the right to recover costs was a result of imperfect collaboration [occasioned by lack of an efficient two-way communication between the two parties]. There were also the issues of faulty information filtering. Rick's computer application produced misleading information, and this impacted his contract relationships. This case law presents a court decision that relates to an integrated scheduling model, similar to BIM. The main lesson here is: where integrity of inputs into a model raises question, recovery from liability could become constrained.

3.2.3 Liability of Parties in Collaboration in Virtual Space

The limitations of BIM include interoperability (Love et al., 2013; Steel et al., 2012), joint and shared liabilities underlying co-contributed model data (Olatunji & Akanmu, 2014b), ownership of intellectual property in integrated models (Olatunji & Akanmu, 2014b), ownership of federated model (Olatunji, 2011), and duty of coordination in a collaboration platform. Legal issues relating to these have yet to be examined by the courts. However, an absence of decided cases does not make the issues less potent.

In *M. A. Mortenson Co. vs. Timberline Software Corp.* (1999), the claimant (Mortenson) claimed a bug in the software used to prepare a bid caused an 'abort' error message. As a result, the claimant was misled by the software into proposing a bid that is $2 million lower than an intended estimate. The software development company (Timberline) was sued for breach of warranties. The trial Court of Washington held that the software purchase order was not an integrated contract and that the license terms [in particular, disclaimers] are a part of the contract. Thus, limitation of remedies was enforceable. An Appeal Court reaffirmed the decision in Washington.

The claimant ordered a bid analysis software from the respondent (Timberline). An acknowledgment and acceptance of the license agreement terms and remedies limitations were prerequisite to using the program. The limitations stipulate no liability for any damages arising from the use or inability to use the program; and if any, however, shall not exceed the license fee paid for the right to use the program. Following the installation of the program, the introductory screen warned that use of the program was governed by its license, thus placing the appellant on notice with sufficient time to appreciate the agreement terms.

Continuing to use the program manifested consent to the terms of the license, which were not found to be illegal or unconscionable. Accordingly, the court, in its wisdom, did not question the respondent's duty of care and consequential damage that was associated with the use of the estimating tools. The limited liability of the software manufacturer, as determined by the court, implies that in BIM-enabled project, there is potential for errors associated with software performance with greater liability to participants to examine the correct performance before transmitting the information through to other processes. However, (Olatunji, 2014) stated that disclaimers do not completely vacate liabilities. The authors use the doctrine of consequential loss to conclude that developers of authoring tools and end-users [i.e. authors] can be found liable. Accordingly, construction law and contracts need to be updated to accommodate the evolving nature of modern technologies. (Newbery, 2012) summarised this concerning BIM and suggested that a careful drafting of contractual provisions is necessary to accommodate its protocol and associated legal issues, and to outline a framework to support the integrative approach to design and the construction that is demanded.

3.2.4 Admissibility of Electronic-based Documents as Court Evidence

Dematerialisation has been debated as a source of concern in evidentiary processes (Lefebvre, 1998). Replacing the culture of paper with digital documentation is a radical change that requires new instruments to support the paradigm shift. Conventional norms only provide for manual sign-off on documents. Universal contracts such as the Joint Contract Tribunal [JCT] and the Federation Internationale des Ingenieurs-Conseils [FIDIC] also treat notices and instructions as a condition precedent to claims, to be written and signed. In addition, FIDIC and Australian Standards (AS 2124) also requires parties to a contract to communicate approvals, certificates, consents, determinations, notices and requests in writing. In turn, this questions the admissibility of electronic documents in arbitration and litigation processes. However, Courts, in some occasions, do qualify printed emails as "in-writing" documents (Christensen et al., 2007). In other occasions, computer-based evidence is considered as third-hand hearsay and electronic notice as a substitute to written notice only if it had been received (*FXCM Securities Ltd vs Michael John Digby, 2013*).

Orifowomo (2012) discusses the necessity to provide electronic transactions in a tangible format for evidentiary purposes. The author clarifies that in the absence of a legal framework that recognises the intrinsic equivalence with paper transactions, proof of electronic document is a considerable challenge.

Nonetheless, available evidence suggests Courts have taken decisions signifying an intent to overcome the challenge. For example, in *Regina vs Minors* (1989), the Court of Appeal in North London held that for a computer print-out to be admissible in evidence, it requires to be accurate and authentic with no grounds to doubts. In *King vs State ex rel. Murdock Acceptance Corp 222 So. 2d 393 (Miss. 1969)*, the print-out records of Murdock electronic computing equipment raised the question of admissibility in evidence. The said records appeared to be entered by competent operators in the regular course of business. Mississippi Supreme Court considered that although best evidence is the best objective, the law has to adjust its rules to accommodate itself to the evolution of the age it serves. It was held that computer print-out of business records are admissible in evidence despite not being paper-based recordings. (Reynis, 2011) also added, that under French law, electronic documents are accepted as evidence.

The American Institute of Architects (AIA) have issued a supplementary contractual document to support the use of BIM (McAdam, 2010). The addendum introduces provision permits digital data exchange and indemnify the data initiator from liability resulted from unauthorised use by others. Therefore, in the absence of express contractual terms, admissibility of digital documents will depend on the local legislation having jurisdiction over the contract, such as emails available in printed copy considered as in-writing document in Australian courts (Sharon et al., 2007). BIM contracts need to construct clear contract language regarding this, which should be based on a standalone project situation or as domain-specific constructs, covering what constitutes authenticity, validity and liabilities in an admissible electronic documents.

3.2.5 Legal Validity of Digital Models

The legal validity of BIM deliverables have been examined, e.g., McAdam (2010) and Arensman and Ozbek (2012). In particular, authors have debated whether design models constitute a contract document. Fundamental engineering practice considers drawings that demonstrate design layout and associated good-for-construction details as part of any construction contract document. Similarly, the American Institute of Architects' (AIA) (2007) General Conditions of the Contract for Construction [also known as AIA A201], refers to project drawings as the pictorial part of contract documents [Section 1.1.5], and other representation forms [e.g. models, specifications and surveys] as instruments of services [Section 1.1.7]. However, the AIA A201 (2007) makes no specific mention of BIM as a part of contract documents, although it considers the possibility of including digital models in the submission of shop drawings. In addition, the AIA E-series documents for digital practice, and other agreement templates – such as the AIA B101 (2007) *Agreement between Owner and Architect* – have neither amended the typical definition of contract documents nor documented for an independent definition for BIM. It will appear, therefore, that there is no universal template to enforce dedicated BIM contracts. Ashcraft (2008) have noted this suggesting that BIM can produce better-quality of design products under a collaborative environment; however, it cannot be relied on as a contract document.

Dougherty (2015) discusses a bi-directional relationship between BIM and 2D drawings which allows either amending the model or the projected drawings to achieve similar amendment to both objects. AIA E202 further acknowledges that BIM supports the creation and extraction of 2D documents. Section 1.1.1 of Indiana University BIM Guidelines (the IU-2012) stipulates that all drawings necessary for the bidding and construction shall be extracted from BIM models. However, BIM is replacement nor a substitute for CAD (Zyskowski, 2009).

BIM must serve its roles to adduce [prove] the expected benefits from its deliverables. Considering designs as a component of pictorial parts of a contract is not sufficient. The models from which the designs are created should be an inherent part of the contract, more-so the legal facilities to drive its deliverables.

3.2.6 Intellectual Property and Ownership Issues

The collaborative nature of BIM processes requires multi contribution from various participants, transmission of and access to massive data throughout design and construction work. Such requirements accordingly brings to the fore the following question; “who owns what?”. Outcomes of collaboration, for example, the federated and the intellectual property underlying the artefact, are jointly owned by the co-contributors, owners and developers of the platform(s) in which the product is domiciled and the client, the owner of the project. Section 1.1.7 of AIA A201 (2007) General Conditions of the Contract for Construction acknowledged the impact of computer technology on Architects’ and other participants’ creative work which includes models, assessment reports, specifications, drawings, sketches etc. and refers to it as instrument of services. Article 7 of AIA B101 (2007) *Standard Form of Agreement Between Owner and Architect* further regulates the authorship of the instrument of services. It stipulates that model authors own the right to their product throughout. In addition, model authors are obligated to grant a non-exclusive license to project owners. AIA’s E203 (2013) states that the receiving party is not entitled to ownerships or rights other than the right to use, amend and to further transmit data to other participants of the project (Section 2.3). Such a right to use model data exceeds design and construction stage, could include the facilities operation phase.

Transmission of digital model, as also stipulated in Article 2, AIA E203 (2013), obligates the transmitting party to warrant ownership of data being transmitted or possess the permission to transmit such data. Similar requirements are stipulated in ConsensusDOCS 301, Building Information Modelling Addendum (Paragraph 6.1). The objective of such requirement is to enable all participants to utilise BIM models, to contribute to the model while fulfilling their contractual obligations during project development processes. (Dougherty, 2015) also clarifies that most BIM guidelines are drafted to facilitate the owner’s entitlement to use federated model after the construction stage. However, this is not by default; model authors have had to agree to the span of client’s requirements and the condition of validity to which the client intends to put the model to use. The State of Ohio BIM Protocol states, regarding ownership of the Model, which digital models and data developed for a project belong to the project owner, who may use of the data as allowed under the laws of the state of Ohio for electronic data and contract document.

A convenient conclusion from extant but random templates regarding ownership issues is as though current suggestions regarding rights' ownership in digital models are still subjective and superficial. Professionals from multiple disciplines undertake model authoring. Under a collaboration arrangement, it is often not strange to find that traditional disciplinary boundaries are challenged, and collaborators could choose to have shared, joint or rotated leadership across multiple disciplines. Views on how this should operate are best synthesised through multidisciplinary consultations. Asides, there is a sensitive side to this, as there are many dimensions to model ownership issues, some of which have not been captured within existing guidelines. For example, one side to this is part of the developers of the platforms in which models are created, stored and manipulated, and whereby authors are authorised to express themselves and to market their services. The strength of design collaboration is only limited to the platform and the modifications that the end-users are allowed to make to the platform. The contract language that supports collaboration should provide specific clarity around this, as well as the integrity of the data secured in the platform. Second is the original input of model authors, co-created jointly by multiple disciplines in the case of a federated model. Collaboration does not deliver outcomes automatically.

According to Olatunji and Akanmu (2015), positive outcomes are best driven when collaboration requirements are well defined around authority and administration of collaborators rights, and mutual accountability. The existing legal framework need to be re-engineered with provisions to ensure that the design model is being used for the intended purpose only. Client's side to these is also crucial; project owners buy out the inputs of model authors. The essence of collaboration is to bring the project team closer to each other and the client. However, collaboration benefit can only be acknowledged when team members in the development processes can participate seamlessly in decision-making processes

3.3 BIM and Procurement Methods

The transmission from fragmented design to BIM collaborative work demands multidisciplinary collaboration and involves intensive communication and interdependence (Ashcraft, 2008). Although BIM provides a consolidated platform for collaborators to communicate and integrate, achieving the required outcomes still depends on the team's willingness to collaborate (Olatunji & Akanmu, 2015). Software compatibility, data exchange and file formats are among the technical interoperability issues that preclude seamless exchanging of information across organisational boundaries. The level of skills and competency "both technological and managerial" of contributors is another challenge that face collaboration (Sher et al., 2009). Furneaux and Kivits (2008) estimates an overall yearly cost of $15.8 billion spent in Australia on users/occupants/operators, which could be saved substantially if BIM interoperability has been increased. Further survey confirms that lack of data interoperability cause US$ 15.8 billion yearly lose in the management of capital facilities in the US (Aranda-Mena et al., 2009).

Nevertheless, collaboration is not a panacea for BIM success. Contributors need to build synergy that aims for long term relationship rather than a limited approach for creating and sharing information.

Contract represents an obligatory document through which parties perform their duty and deliver deliverables (Cheung, 2002). Under partnering contracts, compliance with norms and unstated rules are involved. Ashcraft (2008) argues that this facilitates BIM. Further incentives to implement partnering arrangement is potential value engineering and cost-effective construction, which in turn increase productivity and reduce costs (Bresnen & Marshall, 2000). Bennett et al. (1996) clarify that partnering leads to effective deployment of resources and hence assist contracting parties to respond to market developments as they unfold.

Alliance as a procurement method provides an environment of mutual trust and commitment to share risks (Davis, 2011). When *consensus ad idem* is achieved, parties commit to reach common objectives (Yeung et al., 2007). This approach favours collaboration; information is shared transparently. (Love et al., 2011a) further confirm that sharing risk and reward is the prime objective of an alliance; thus parties in BIM-enabled project are still required to work cooperatively in alignment with such objectives.

Design-Bid-Build (DBB) is a procurement method in which design is completed before the commencement of construction (Ling et al., 2004). It provides an opportunity to receive competitive bid, however, separates design from construction, thus obstruct communication between both teams. (Porwal & Hewage, 2012) present BIM-partnering method as a possible extension to DBB, where contractor and consultant participate together in design coordination via a collaborative process.

BIM-partnering method is a framework of BIM-based design collaboration that encompasses five different management phases. It starts with the planning phase where a feasibility study is developed to validate the intended business, followed by modelling phase where BIM-Partnering contract is executed for onward preparation of tender. Partnering award phase is to follow during which bids are received and partnering contractor is appointed. BIM-Partnering phase is the final phase where complete design is developed. Accordingly, all parties work together under a collaboration framework to develop all engineering discipline models for onward integration with the early architectural model and eventual creation of the federated model. Incorporating BIM-partnering approach in DBB obligates the contractor to share liability for design model.

Design-Build (DB) on the other hand permits early involvement of contractor and early commencement of construction works as design development unfolds (Hale et al., 2009), thus joint commitment to BIM integrated collaboration, and hence better cost and time control. The literature confirms that DB procurement method result in less time and cost schedule to achieve completion, although performance is pretty much controlled by construction team experience and competency. Love et al. (1998) opine that DB and Partnering facilitates the integration of project team members under atmosphere of creativity and innovation, which in turn motivate inter-firm collaboration to resolve differences amicably rather than arbitration or litigation process. Tsai et al. (2014) argue that combination of BIM and DB method results in strong environment of coordination; thus delivery of unambiguous, well consistent design drawings and eventually strengthen construction performance and increase client's satisfaction remarkably.

3.4 Summary

This chapter presented a practical outline of typical claims concepts including scope change, acceleration, delay, disruption, and claims in tort. Disputes are a fundamental element of the industry with a very long history. Even "good" projects might have claims and disputes. Change is a fact of life in design, engineering and construction projects. Inevitably, some of those changes may lead to disputes between parties. Almost all contracts in the AEC sector are written to address the tendency towards change in the designing, engineering and building of things. For example, finding a contract for even the smallest of projects that does not include definitions and clauses regarding change orders, extensions of time, liquidated damages, and methods and procedures regarding dispute resolution would be the isolated exception as opposed to the rule. Legal jurisdictions around the world (both common law and civil law) have means and methods for articulating legal causes of action, interpreting contract clauses and the contemplation of monetary damages.

BIM technologies and processes, with their inherent transparency and collaborative approach, will enable clearer anticipation and better management of change in the first instance, thereby reducing the potential for claims leading to disputes and potential litigation. This is because the use of BIM can profoundly and directly alter the production, delivery, and constitution of construction documents/drawings, quantity surveys, budgets/estimates, field-execution methods, and project schedules each of which are central and critical components in the analysis of claims and dispute.

CHAPTER 4 RESEARCH METHODOLOGY

4.1 Chapter Introduction

An appropriate selection of research methodology is extremely important for any research, not only to collect data efficiently but also to ensure research validity.

This chapter explains and justifies the philosophical basis and the validity of the research methodology adopted for this research. The limitations and challenges associated with the methodology are also presented and discussed.

This chapter presents the basis of the methodology supporting the development of a collaborative contractual framework to facilitate BIM-enabled projects, discusses the threats to research validity and presents some techniques for overcoming them. The methodology used proved to be effective in achieving the intended objectives and therefore, can be helpful for similar forthcoming research.

4.2 Research Strategy

Qualitative research seeks to understand phenomena in context-specific settings, whereby the researcher does not attempt to manipulate the phenomenon of interest (Patton, 2005). Qualitative research, as a definition, can be regarded as "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (Strauss & Corbin, 1997) and instead, the kind of research that produces findings arrived from real-world settings where the "phenomenon of interest unfold naturally" (Patton, 2005). Qualitative researchers seek explanation/clarification, understanding, and deduction from similar situations (Hoepfl, 1997) instead.

Qualitative research methodology facilitates a better understanding of a phenomenon about which little is yet known (Strauss & Corbin, 1990). It is anticipated that qualitative research results in a new perspective with more in-depth information to adequately describe or interpret the targeted findings.

Qualitative analysis produces a type of knowledge where one party argues from the underlying philosophical nature of each paradigm, utilising detailed interviewing while the other focuses on the apparent compatibility of the research methods, "enjoying the rewards of both numbers and words" (Henze, 1995, p. 598). As such, methods like interviews and observations are dominant in a naturalist (interpretive) paradigm and supplementary in the positive paradigm, where the use of survey serves in opposite order. (Patton, 2005) supports the notion of the researcher's involvement and engagement in the research by noting the real world is subject to change and therefore, a qualitative researcher should be present during the changes to record an event after and before the change occurs.

Developing a BIM collaboration model is faced with challenges. Such challenges are; each engineering discipline has its unique perspective; a large number of evaluation parameters must be considered; conflicts and/or dependencies always exist, and several relevant parameters are excessively subjective (Ghaffarianhoseini et al., 2017; Renger et al., 2008). Thus, to design a qualitative study Robson and McCartan (2016) suggested that the research design needs to be flexible and inductive rather than fixed developed from an initial decision. Therefore developing or borrowing a logical strategy in advance for onward implementation is not possible but to construct and reconstruct the research design throughout the study. According to Maxwell (2012), any research design need to consider five main components as listed below:

- objectives: the purpose of the intended study and the issues to clarify
- conceptual framework: reviewing prior research findings, existing theories and relevant literature;
- research questions: construct the questions to best capture the intended learnings and understandings;
- methods: decide the approaches and techniques for data collection and analysis. This includes identifying the spectrum of participants, data sources “sampling”, data collection methods, data analysis strategies; and
- validity: the possible threats to the expected results and conclusions and reasonable alternative interpretations to support the ideas

Chapter 1 identified the aim and objectives of this research and argued that a methodological challenge for the research lies in providing an incentive to cooperate for the industry participants. Based on previous behavioural decision research, systematic elicitation and deliberative procedures encourage people to cooperate. Therefore identifying the factors that influence collaboration was the first thing to consider in this research.

The previous collaboration theories and models that have been examined in Chapter 2 indicated an important hint of respect to the approach that this research would need. For instance, the studies undertaken by (Hughes et al., 2012; Matthews et al., 2018; Rezgui et al., 2013) focussed on deriving the essential aspects to collaboration mainly through the use of interviews for data collection process. The process resulted in identifying and examining the collaboration inhibitors and enablers in construction. The information that the researchers collected was subsequently used to gain an in-depth understanding of the collaboration challenges. In essence, the semi-structured interviews approach where questions are pre-planned and through the use of open-ended questions simulates avenues of interest to be pursued as they arose without introducing bias in the response (Bryman, 2016; Dörnyei, 2007).

The concept of semi-structured interviews is based on the assumption that prepared questioning guided by identified themes facilitates a conversation that is directed towards topics and issues to elicit more elaborate answers (Qu & Dumay, 2011). The focus on an interview guide ensures a thematic approach is applied throughout the interview. Brinkmann and Kvale (2015) clarify that the basis that semi-structured interview has in human conversation makes it a very convenient and effective means to gather information. Through the use of such an approach, the style, pace and ordering of conversation can be modified to induce the fullest replies from interviewees.

Black (1993) suggest that for research to achieve its identified objectives, the required data need to be collected, and thus the design methodology should be selected on such basis. Accordingly, the methodological design for this research was developed following careful consideration of that data that is needed to support the realisation of the objectives as stipulated in Chapter 1.

Creswell and Creswell (2017) clarify that connecting the findings derived from experimental studies to the initial question(s) and eventual conclusion(s) represent a research design. In this thesis, the research design was based on a qualitative approach, whereby qualitative method (literature review and semi-structured interviews) is used to study the research topic (Figure 4.1). Researchers advocated the qualitative approach, which have been more widely adopted in studies across social and natural sciences (Chan et al., 2008; Davis & Stevenson, 2001; Dyson et al., 2016; Gameson & Sher, 2009; Lin & Gregor, 2006; Peansupap & Walker, 2005). Figure 4.1 illustrates that this research was undertaken following the procedures below:

- undertaking an investigative study “literature review” to establish the interdependencies of all factors associated with collaboration;
- conducting semi-structured interviews with experienced respondents and develop a conceptual collaboration model;
- testing and verifying the legal feasibility of the conceptual model with reference to precedent case laws and court judgments; and
- validate the collaboration model by conduction another session of semi-structured interviews and modify the model and associated hypothesis.

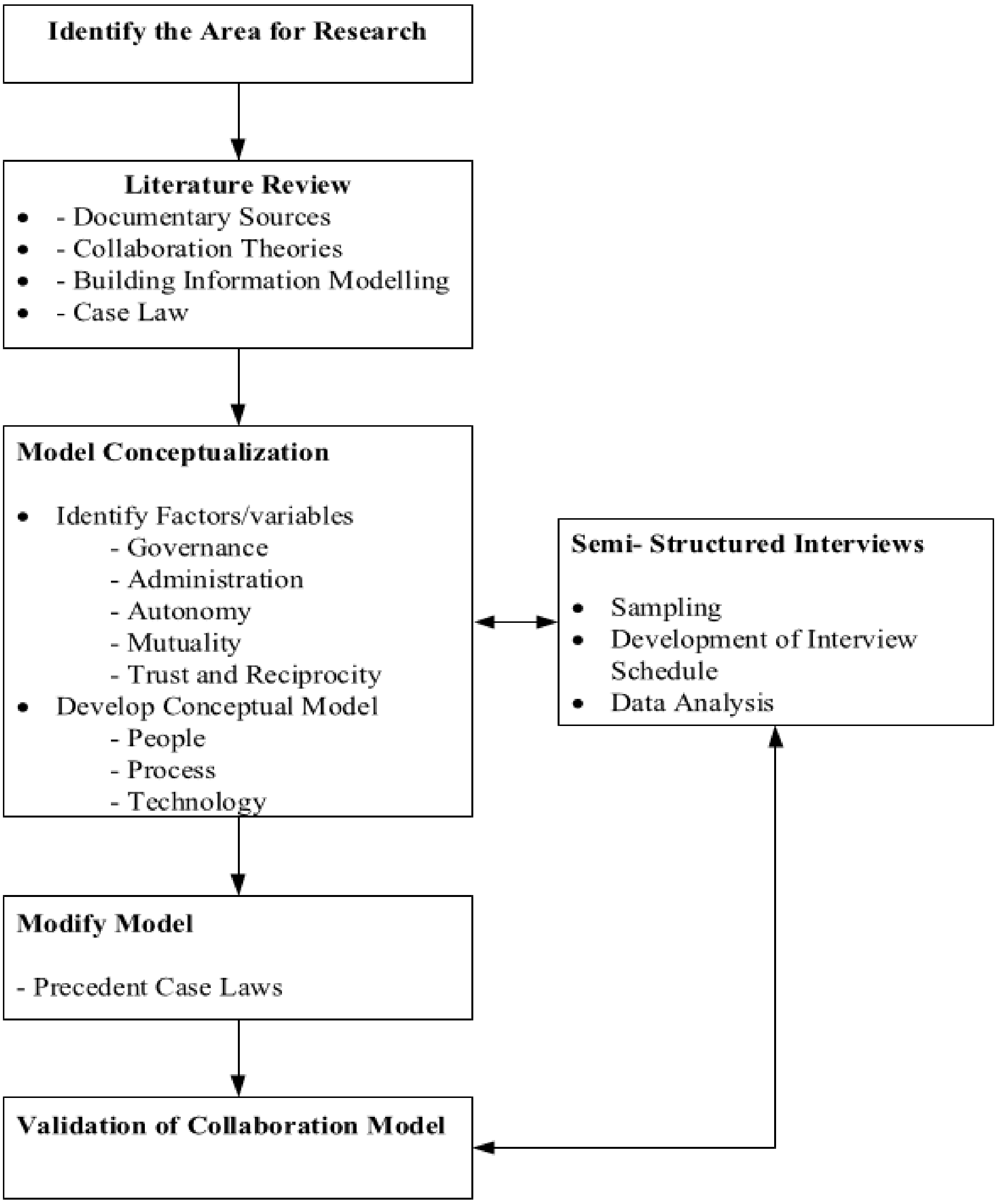


Figure 4. 1 Research design and strategy

As denoted by Figure 4.1, the knowledge derived from literature review and that from semi-structured interviews were utilised to develop a conceptual model for collaborative work in the context of BIM. The said model was then tested by referring to precedent case laws and further validated by conducting another session of semi-structured interviews with purposively selected respondents from s sampling frame. Notably, the role of the case laws in this research was critical because they examined the legal feasibility of the developed conceptual framework and highlighted the compliance of the proposed collaboration dimensions and associated variables with the existing legal structure.

De Vaus and de Vaus (2013) clarify that the process of construction and examining a theory forms part of the overall research process. Testing a theory must focus on evaluating the variance between the anticipated and observed responses, and that researches, if considerable variance exist, should attempt to justify and explain the reason behind the significant variance. Interviews with the industry experts were conducted in the early stage of this research to identify the main collaboration dimensions and the impact on BIM implementation. The findings collected from the interviews have identified collaboration deficiencies and challenges. Neely et al. (2005) support the opinion that identifying the problems facilitates better understanding and hence successful development and implementation of a new approach within the organisation.

4.3 Justification of Research Approach

The longstanding argument about the adequacy of research methods in social science has triggered a concern that has been growing over the years. Although organisational research used to be dominated by an abstracted empiricism based on the use of quantitative methods, a call is being raised in support of qualitative methods (Dainty, 2008). However, researchers such as (Love et al., 2002) stated "Research in construction management can be categorised as being at the intersection of natural science and social science" (p.294), which in turn suggests that empirical research in construction management is likely to be dominated by both methodologies; the positivism which promoted an orthodoxy to study the social phenomena and human behaviour via the application of "natural science", and interpretivism as an alternative paradigm, advocate the importance of studying participants via "social science".

Research methodology is not just a method used in particular research but the amalgamation of rational and philosophical assumptions that motivate a study. Therefore cannot be viewed in isolation from the ontological and epistemological positions that the researcher adopt.

In philosophy, the formations of reality is the reference to ontology, where objectivist ontology views social phenomena independently from social actions, while constructivist ontology deduces that social phenomena are resulted by social interface, and are therefore in an unbroken state of revision (Bell et al., 2018). Fuller (2002) clarifies that what is regarded as an acceptable knowledge in a discipline is a reference to epistemology. It is imperative to understand the impact of opposing paradigms on how to research to appreciate the corresponding contribution to knowledge. Research paradigm is defined by Bryman (2003) as ”cluster of beliefs and dictates which for scientists in a particular discipline influence what should be studied, [and] how research should be done”, therefore different kind of knowledge is generated by different research paradigms.

The research design provides a framework for undertaking the research which includes data collection and analysis that is required to answer the research questions (Bell et al., 2018). Qualitative research utilises an interpretive approach, where researchers are attempting to interpret, phenomena in terms of the meaning that people bring to them (Denzin & Lincoln, 1994). Qualitative approach preserves the complexities of human behaviour through holistic perspective (Black, 1994), which in turn helps to understand the strengths and interaction between collaboration variables that are unclear, and addresses the causation through the interpretation of events. Such attributes will greatly enhance construction management research (Hallowell & Gambatese, 2010).

4.3.1 Positivist Approach

The positivist approach emphasis understanding the world within the context of the natural science. It places emphasis on facts, as distinct from values or meaning, and the use of the scientific method by which theory is deduced as a result of generating and testing hypotheses (Hughes & Sharrock, 2016). The ontology of positivism is based on a belief that the world is external and a single objective reality exists for any research phenomenon (Hudson & Ozanne, 1988). Hence, positivist researchers primarily adopt a structured and controlled approach, with a clearly identified topic and constructed hypotheses, when undertaking their research. Positivist researchers are isolated from the participants of the research, creating a distance and making an explicit distinction between science and personal experience (Carson et al., 2001). Essentially, a positivist can identify causes and effects through “the constant conjunction” of events, resulting in what has been called the “covering law” orthodoxy (Popper, 2005). This orthodoxy can be essentially devoted to the pursuit of explanations, which take the form of general laws. In contrast with interpretivism, deductive reasoning that emphasis "top-down" logic plays a major role in positivism. Babbie (2015) clarifies that in empirical research, "both induction and deduction are essential to the process of the hypothetico-deductive scientific method" (p.45)

As mentioned above, the generalisations derived from the data can result in general law by repeatedly testing and confirming them. According to Popper (2005), theories cannot be conclusively proven from repeated observations that confirm them; however, they are able to be disconfirmed or falsified by just one instance where their predictions are not confirmed. Fundamentally, the epistemological position of an interpretive perspective rejects the natural sciences as an appropriate base for social science inquiry (Hudson & Ozanne, 1988).

- Reliability in Quantitative Research

Bouma and Carland (2016) clarify that the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable.

Embodied in this citation is the idea of replicability or repeatability of results or observations. Golafshani (2003) identifies three types of reliability referred to in quantitative research, which relate to: (1) the degree to which a measurement, given repeatedly, remains the same (2) the stability of a measurement over time; and (3) the similarity of measurements within a given time period. Mertler (2018) adheres to the notions that consistency with which questionnaire [test] items are answered or individual's scores remain relatively the same can be determined through the test-retest method at two different times. This attribute of the instrument is actually referred to as stability. If we are dealing with a stable measure, then the results should be similar. A high degree of stability indicates a high degree of reliability, which means the results are repeatable. Joppe (2000) detects a problem with the test-retest method which can make the instrument, to a certain degree, unreliable. She explains that test-retest method may sensitize the respondent to the subject matter, and hence influence the responses given. We cannot be sure that there was no change in extraneous influences such as an attitude change that has occurred. This could lead to a difference in the responses provided. Similarly, (Crocker & Algina, 1986) note that when a respondent answer a set of test items, the score obtained represents only a limited sample of behaviour. As a result, the scores may change due to some characteristic of the respondent, which may lead to errors of measurement. These kinds of errors will reduce the accuracy and consistency of the instrument and the test scores. Hence, it is the researchers' responsibility to assure high consistency and accuracy of the tests and scores. Thus, (Crocker & Algina, 1986) say, "Test developers have a responsibility of demonstrating the reliability of scores from their tests" (p.372)

Although the researcher may be able to prove the research instrument repeatability and internal consistency, and, therefore reliability, the instrument itself may not be valid.

- Validity in Quantitative Research

The traditional criteria for validity find their roots in a positivist tradition, and to an extent, positivism has been defined by a systematic theory of validity. Within the positivist terminology, validity resided amongst, and was the result and culmination of other empirical conceptions: universal laws, evidence, objectivity, truth, actuality, deduction, reason, fact and mathematical data to name just a few (Winter, 2000)

Wainer and Braun (2013) describe the validity in quantitative research as "construct validity". The construct is the initial concept, notion, question or hypothesis that determines which data is to be gathered and how it is to be gathered. They also assert that quantitative researchers actively cause or affect the interplay between construct and data in order to validate their investigation, usually by the application of a test or other process. In this sense, the involvement of the researchers in the research process would greatly reduce the validity of a test.

Insofar as the definitions of reliability and validity in quantitative research reveal two strands: Firstly, with regards to reliability, whether the result is replicable. Secondly, with regards to validity, whether the means of measurement are accurate and whether they are actually measuring what they are intended to measure.

However, the concepts of reliability and validity are viewed differently by qualitative researchers who strongly consider these concepts defined in quantitative terms as inadequate. In other words, these terms as defined in quantitative terms may not apply to the qualitative research paradigm. The question of replicability in the results does not concern them (Glesne, 2016), but precision (Winter, 2000), credibility, and transferability (Hoepfl, 1997) provide the lenses of evaluating the findings of a qualitative research. In this context, the two research approaches or perspectives are essentially different paradigms measures (Tashakkori et al., 2000).

4.3.2 Interpretivist Approach

The ability to address the complexity and meaning of situations (Black, 2006) with focus on what data is required to imply “theory” is the strength of interpretivist approach. (Hudson & Ozanne, 1988) clarify that realities are multiple and relative, which mimic the belief of interpretivism relating to ontology and epistemology. The fact that these realities are hard to construe in terms of fixed realities is derived from that other systems underpin them for their meanings (Lincoln, 2007); (Bernard & Bernard, 2013). Flexible structures, as opposed to structural frameworks, is what interpretivist approach adopts. Carson et al. (2001) clarify that flexible frameworks are inclined to deriving the meaning of human interactions and capturing what is realised as reality. While investigating topics of interest and with the help of experts, interpretivist researchers experience new knowledge, upon which they build into the research context based on prior insight. Hudson and Ozanne (1988) argue that a fixed research design can’t be developed based on the referred to insight due to the problematic and complex nature of what is assumed as reality. Therefore interpretivist research is dominated by inductive interpretation, whereby reasoning commences from specific data and proceed to general law.

- Reliability in Qualitative Research

Although the term ‘Reliability’ is a concept used for testing or evaluating quantitative research, the idea is most often used in all kinds of research. If we see the idea of testing as a way of information elicitation then the most important test of any qualitative study is its quality. Eisner (2017) clarifies that a good qualitative study can help us “understand a situation that would otherwise be enigmatic or confusing” (p.96). This relates to the concept of a good quality research when reliability is a concept to evaluate quality in quantitative study with a "purpose of explaining" while quality concept in qualitative study has the purpose of "generating understanding" (Stenbacka, 2001). The difference in purposes of evaluating the quality of studies in quantitative and quantitative research is one of the reasons that the concept of reliability is irrelevant in qualitative research. According to Stenbacka (2001) "the concept of reliability is even misleading in qualitative research. If a qualitative study is discussed with reliability as a criterion, the consequence is rather that the study is no good" (p.552).

On the other hand, Patton (2005) states that validity and reliability are two factors which any qualitative researcher should be concerned about while designing a study, analysing results and judging the quality of the study. This corresponds to the question raised by Lincoln and Guba (1985) that "How can an inquirer persuade his or her audiences that the research findings of an inquiry are worth paying attention to?" (p.123). To answer to the question, Healy and Perry (2000) assert that the quality of a study in each paradigm should be judged by its own paradigm's terms. For example, while the terms Reliability and Validity are essential criterion for quality in quantitative paradigms, in qualitative paradigms the terms Credibility, Neutrality or Confirmability, Consistency or Dependability and Applicability or Transferability are to be the essential criteria for quality (Lincoln & Guba, 1985).

Lincoln and Guba (1985) use "dependability", in qualitative research which closely corresponds to the notion of "reliability" in quantitative research. They further emphasize "inquiry audit" as one measure which might enhance the dependability of qualitative research. This can be used to examine both the process and the product of the research for consistency (Hoepfl, 1997). To ensure reliability in qualitative research, examination of trustworthiness is crucial. Seale (1999), while establishing good quality studies through reliability and validity in qualitative research, states that the "trustworthiness of a research report lies at the heart of issues conventionally discussed as validity and reliability" (p.467).

To widen the spectrum of conceptualization of reliability and revealing the congruence of reliability and validity in qualitative research, Lincoln and Guba (1985) states that: "Since there can be no validity without reliability, a demonstration of the former [validity] is sufficient to establish the latter [reliability;]" (p.128). Patton (2005) with regards to the researcher's ability and skill in any qualitative research also states that reliability is a consequence of the validity in a study.

- Validity in Qualitative Research

The concept of validity is described by a wide range of terms in qualitative studies. Winter (2000) states that validity is not a single, fixed or universal concept, but "rather a contingent construct, inescapably grounded in the processes and intentions of particular research methodologies and projects" (p.5). Although some qualitative researchers have argued that the term validity is not applicable to qualitative research, but at the same time, they have realised the need for some kind of qualifying check or measure for their research. For example, Creswell and Miller (2000) suggest that the validity is affected by the researcher's perception of validity in the study and his/her choice of paradigm assumption. As a result, many researchers have developed their own concepts of validity and have often generated or adopted what they consider to be more appropriate terms, such as, quality, rigor and trustworthiness (Davies & Dodd, 2002)

The issue of validity in qualitative research has not been disregarded by Stenbacka (2001) as she has for the issue of reliability in qualitative research. Instead, she argues that the concept of validity should be redefined for qualitative researches. Stenbacka (2001) describes the notion of reliability as one of the quality concepts in qualitative research which "to be solved in order to claim a study as part of proper research" (p.558). In searching for the meaning of rigor in research, Davies and Dodd (2002) find that the term rigor in research appears in reference to the discussion about reliability and validity, and argue that the application of the notion rigor in qualitative research should differ from those in quantitative research by "accepting that there is a quantitative bias in the concept of rigor, we now move on to develop our preconception of rigor by exploring subjectivity, reflexivity, and the social interaction of interviewing" (p.279). Therefore if issues of reliability, validity, trustworthiness, quality and rigor are meant differentiating a 'good' from 'bad' research then testing and increasing the reliability, validity, trustworthiness, quality and rigor will be important to the research in any paradigm.

4.3.3 Approach for the Research on Collaboration

A barrier to the use of positivist approach for this research originates from the nature of the principle participants involved in BIM enables projects. If a positivist ontology was assumed, the participants being involved in the research would be considered to be uniform and passive agents who do nothing more than observe and record the conjunction of events. (Love et al., 2002) argue that under this view, “the social system that exists in a project would be taken to be no more than the sum of the individuals” (p.296)

The dynamic approach of construction management focuses on flexibility and team contribution; wherein different project parties are integrated under a collaborative environment and based on suitable and certain relationships. However, Gofus et al. (2006) argue that collaboration is the most critical production of organisations. The involvement of various engineering disciplines throughout the multiple stages of construction project development (Shen et al., 2010) resulted in a complex construction industry with complicated stakeholder networks and execution processes. Love et al. (2002) state “Construction projects are extremely dynamic and complex and invariably consist of multiple interdependent components” (p.296), therefore multiple communication and information sharing processes.

Team members deal with the changes and contingencies as they unfold via scheduled process of planning, motivating and controlling. Understanding such multifaceted, contextualised and developing process, facilitates insights on how cultures shape communication. Human relation that relies on the contribution of individuals is the essential approach of collaboration in construction projects, therefore understanding and predicting human behaviour is the main challenge to manage such projects.

In a critical and holistic sense, this research needs to study the concepts of truthfulness, beliefs and accountability within stakeholder groups. The conclusive role that human issues maintain in performance management makes it critical to interpreting the perspectives of stakeholders and practitioners (Neely et al., 2005) at interpersonal, organisational, social and professional levels. A flexible type of approach where intuition is blended with the process of discovery is best suited to achieve the required potentials (Daymon & Holloway, 2010).

Denzin and Lincoln (2002) state “Properly understood, qualitative enquiry becomes a civic, participatory, collaborative project…that joins the researcher with the researched in an on-going moral dialogue” (p.xi). With the provision of effective investigatory tools, qualitative research process generates knowledge in conjunction with research participants in some aspect of interpretation. Edwards and Kreshel (2008) acknowledge that qualitative investigations result in unique insights as such investigation are carried out in contributors’ natural settings and environment.

Despite the strengths of qualitative research that a plethora of studies advocate, those holding to an opposite orientation raise their concern against qualitative studies of being too impressionistic and subjective (Bryman, 2016). Nevertheless, pragmatists believe that reality is only accessible through interpretations and perceptions. It exists independently from those who observe it (Ritchie et al., 2013).

4.4 Exploratory Study

As introduced above, the basic research strategy of this thesis is the inductive method. Therefore, a qualitative exploratory study which is prevalent in such research was undertaken for both conceptualisation and model validation. Babbie (2015) clarify that exploratory research facilitates the determination of research design and data collection, and further argue that conducting expletory research helps to provide insights and derive conclusions into the given situation. Research topic and associated questions can be framed and refined through the application of expletory research, and hence develop a research method and present its conceptualisation (Nunes et al., 2010). Understanding and interpreting the preliminary information is the main objective of the expletory study, and subsequently build with such understanding a conceptual framework (Kotler & Armstrong, 2010).

As clarified by De Vaus and de Vaus (2013), Initiating the exploratory studies should occur before the main research due to their critical impact. Nunes et al. (2010) state “exploratory studies are an invaluable source of contextual data, which have the ability of moving the researchers into the phenomenon's ecology and the core of respondents' accounts, thus partitioning the broad emergent theory into workable, theoretically-relevant conceptual units" (p.75). Data resulted from exploratory studies helps to identify the research gaps; moreover, Babbie (2007) argue that exploratory studies dominate social science, where questions (ex. 'what', 'how', and 'why') can be addressed and subsequently valuable conceptual themes are generated from the data itself.

Nunes et al. (2010) clarify that exploratory studies depends on literature review and/or qualitative approaches which are dominated by in-depth interviews. An exploratory research can form the initial stage of a study where qualitative data collection is utilised. The analysis of the collected data and resulted outcomes can then be used to design the second stage of the study (Tashakkori et al., 1998). Exploratory studies facilitate better understanding of risks and uncertainties associated with the project's processes (Turner, 2005). Collaboration as clarified earlier contains different dimensions with various variables and complex processes, and therefore conducting exploratory study for this research is rational and necessary.

4.5 Data Collection of Qualitative Research

4.5.1 Data Collection Strategy

A preliminary consideration to data requirements and collection strategy is a good discipline. It is imperative to ensure that an appropriate set of data is obtained to realise the objectives (Fellows & Liu, 2015). As explained earlier, in this research, a qualitative approach was applied; thus, interviews was the adopted method to collect data from the exploratory study.

Table 4.1 summarises the advantages and disadvantages associated with interviews. However, despite the disadvantages, interviews which include semi-structured interviews are considered as two-way communication methods, whereby feedback and gathering of further data via probing are permitted. Rogers and Kincaid (1981) assert that interviews as non-linear methods provide interaction in data collection and thus are more conducive to the transfer of meaning. The interviews were conducted with industry experts of sound experience in BIM-enabled projects. Interviewees' offices were the usual venues of the interviews. The importance to obtain reliable and unambiguous information about collaboration approaches was emphasised to all interviewees.

Table 4. 1 Key issues of the data collection methods in qualitative studies

Method	Advantages	Dis-advantages
Interviews	Wider coverage of topics and features of the procurement process; building of trust; and in-depth understanding of respondents' points of view and interpretations.	Sampling problems; bias of respondents; and difficulty in analysing and interpreting responses to open-ended questions

Adopted from (Bowditch, 1982; Sutherland & Legasto, 1978)

4.5.2 Interview Technique

As a source of collecting primary data, interviews were used as a primary source of data to determine the collaboration main dimensions and associated variables. The collected data was then utilised to structure a collaboration framework which was subsequently verified with reference to precedent case laws and court judgments. Interviews were once again used as a secondary source of data to confirm and refine the resulted conceptual framework.

Describing the interview process, Charmaz (1995) states "we start with the experiencing person and try to share his or her subjective view. Out task is objective in the sense that we try to describe it with depth and detail. In doing so, we try to represent the person's view fairly and to portray it as consistent with his or her meanings" (p.54). The desire to be objective is emphasised in this statement, albeit that objectivity is limited to the researcher's interpretation of interviewees' views and eventual production of detailed description. Miller and Glassner (1997) state "Research cannot provide the mirror reflection of the social world that positivists strive for, but it may provide access to the meanings people attribute to their experiences and social world" (p.100). Therefore it is imperative to make the subjectivity visible throughout the research process. In this research, all aspects of 'what', 'when', 'how', 'why' and the like have been scrupulously recorded.

Gubrium and Holstein (1997) echo Garfinkel (1967) stressing that “all knowledge is created from actions undertaken to obtain it” (pp.113-114). As such interviewing is described by Baker (1997) as “...interviewing is … an international event…questions are a central part of the data and cannot be viewed as neutral invitations to speak…they shape how and as a member of which categories the respondents should peak,…interview responses are treated more as accounts rather than reports…” (p.131).

Interviews vary in nature to correspond with the constraints that are placed on the researcher and interviewee. Dunn (2005) placed the three types of interviews along a continuum and explained the characteristics of semi-structured interviews “Structured interviews follow a predetermined and standardised list of questions. The questions are always asked in almost the same way and in the same order. At the other end of the continuum are unstructured forms of interviewing such as oral histories . . . The conversation in these interviews is actually directed by the informant rather than by the set questions. In the middle of this continuum are semi-structured interviews. This form of interviewing has some degree of predetermined order but still, ensures flexibility in the way issues are addressed by the informant” (p.80). Therefore, this research has implemented semi-structured interviews which, Longhurst (2003) argue as one of the most commonly used qualitative methods. List of predetermined questions are asked; however, respondents are allowed to explore issues as they deem important, which further explore particular themes (Oates, 2006), and facilitate the expression of diverse perceptions (Cridland et al., 2015).

An explicit display of the assumed collaboration components and directly questioning the respondents about the propositions of collaboration framework would compromise the integrity of respondents’ answers. Therefore the notion of a “hidden agenda”, was implemented whereby the researcher’s particular area of interest was not shared with the respondents, which in turn avoided bias in the respondents’ responses. The inherited assumption in the research was that all respondents possessed a sound understanding of the research problem.

Oppenheim (1992) refers to the “hidden agenda” and argue that “the hidden agenda is only hidden in the sense it should not be too obvious to the respondent” (p.70).

However, misinterpretation or manipulation to respondents' answers by the interviewer can cause bias in the data collected form interviews. Love (2001) clarifies that such bias need to be avoided, and thus researchers should attempt to "act as neutral medium through which questions and answers (are) transmitted" (p.75). Briggs (1986) clarifies that unbalanced questions and biased data can be avoided through maintaining the fiction of an interesting conversation, which this qualitative research has ensured to collect impartial data.

The researcher avoided the communication of any sort of ideas that could influence the respondent's answer and carefully recorded all verbal and non-verbal responses from respondents' end — facial expressions such as smiling, nodding when failure to answer the question were avoided. Transcripts of interviews were made available to respondents to examine and confirm the accuracy of their recorded responses.

Digital recording was another requirement that the researcher made sure to clarify with the respondents and obtain their consent to implement. Respondents confirmed their no-objection to record the interviews. The audio record accordingly encouraged fluency, enabled the researcher to observe the responses closely, take note of direct quotations to include in the reports, and allowed close attention to respondents' tone.

The digital records of interviews were transcribed, and accuracy checked. As mentioned earlier, respondents' offices were the main avenue for interviews, which maintained quiet environments. Participants agreed that digital recording on their interviews would be beneficial for further interpretation. The following measures have been implemented to check accuracy:

- spot-checking: by selecting random interviews and listening to the entire taped interviews of the corresponding transcripts while checking the transcripts;
- misinterpretation of content: go through the entire transcription content and highlight any mistakes in typing. Go back to the original audiotape to hear what was actually said and consequently correct the transcript;
- unfamiliar terminology: familiarizing transcriptionists with specific terms and jargon prior to beginning the first transcription of an interview

- inaudible sections: establish guidelines for alerting the researcher to sections that the transcriptionist was unable to understand

4.5.3 Sampling

This research consisted of several phases, started with selecting the topic and ended with the propagation of the eventual findings. Due to the potential influence of each phase on the research outcomes, it was imperative to avoid errors as much as possible during all phases to increase the credibility of the results. Avoiding errors in such type of research where interviews are the main means for data collection is a major challenge. Non-respondents can distort the final results of research and if response rates are low or particular groups are unrepresented within the whole sample, valid conclusions cannot be drawn. It was therefore decided to include representatives from various engineering disciplines and of different professions such as contractors, designers, quantity surveyors, university professors, developers, government agents...etc to overcome any possible bias. The broad selection of interviewees have improved the representativeness of the sample and improved the validity of the findings. Interviews length ranged between 60-90 minutes. A one-on-one was the basis for all interviews. Interviewees were allowed to talk freely without any interruption or interventions, which accordingly helped to achieve an explicit understanding of interviewees' ideas and perspectives on the research topic.

4.5.4 Development of the Interview Schedule

Denzin (2017) clarify that a faulty design in the development of research tool would misrepresent the final results of a research. Therefore it was critical to develop an interview schedule that is adequately investigative to elicit perceptions and sufficiently standardised to facilitate comparability between respondents during analysis. Moving from general areas to the project's related aspects is the tendency of the interview questions (Oppenheim, 1992), which had been already identified following the literature review. The broad areas of the interview questions were then broken down to more manageable groupings with notes detailing the purpose for their inclusions.

Bailey (2008) suspected that an internal testing is required to evaluate the first draft of interview questions, which amounts to a preliminary assessment to identify any ambiguities, discuss and correct leading questions and general criticism. Therefore rigorous assessment was applied to the final pilot draft to ascertain the following:

- whether respondents could and would answer the questions asked during the interview; and
- whether the interview schedule would elicit true differences in the perceptions and views towards the need for, and the experiences of collaboration in BIM-enabled projects.

The pilot phase enabled informed decisions to apply changes and adjust the interview schedule before commencing the collection of main data. Ambiguous questions were modified, and questions sequence adjusted to correspond logically with the interviewees' experience. Accordingly, an interview protocol was developed as illustrated in Appendix A, and based on which the semi-structured interviews were conducted. Several BIM experts from different disciplines and backgrounds were interviewed. The interviews were held in different locations in Western Australia. The data collected from the semi-structured interviews were rigorously examined to search for a pattern, relationships and identify the variables and the differences from the previous researches' findings. NVivo (version 12) software was utilised for the textual data analysis which helped to develop data codes and themes, manage the data and keep track of records in a methodical, thorough and attentive manner, which in turn increased the research accuracy and transparency (Bazeley & Jackson, 2013).

The software accepted the word format of the transcripts, and accordingly, coding commenced where extracts are put together into nodes. The coding process was effective and efficient as oppose to a copy and paste manual coding process. As illustrated in Appendix C, a matrix of categorised data against the different professions was developed and used to group the statement of respondents for further discussion.

4.6 Chapter Summary

The research has adopted design and methodology that provided an original approach to identifying the collaboration dimensions and factors that influence collaboration in BIM-enabled projects. Detailed justification for the philosophical basis of the adopted research approach was provided vide this chapter. The semi-structured interview approach was described along with the process for data collection. The reliability, validity, and limitations that are associated with the semi-structured were also addressed and discussed. The development of semi-structured interview protocol, the sample design and sample size, and justification for the data analysis adopted, reliability and validity of the research instrument, and limitations are discussed in detail.

The methodological approaches adopted in pursuing this thesis were found to be useful in seeking answers to the aim and objectives of the research and the conceptual framework that was proposed. The findings from the semi-structured interviews were then used to develop a conceptual governance framework which is presented in chapter 5. Precedents from case-law were used to legitimise the core dimensions of collaboration, and detailed discussion can be found in chapter 6. Finally, chapter 7 presents the validation of the developed governance framework using in-depth semi-structured interviews.

CHAPTER 5 GOVERNANCE FRAMEWORK

5.1 Chapter Introduction

Aiming at understanding the collaboration and associated variables that impact the implementation of BIM, an exploratory study was conducted. This chapter presents the interpretivist approach that this research used to empirically interpret the prevailing collaboration challenges within the context of BIM. The study employed rigorous data collection method in the form of semi-structured interviews to yield more descriptive results. All interviews were conducted with representatives from various engineering disciplines and of different professions such as contractors, designers, quantity surveyors, university professors, developers, government agents. All interviewees had substantial experience in the construction and delivery of BIM-enabled projects across Australia states.

The challenges and shortfalls that engender collaboration in practice were highlighted during the interviews. List of artefacts related to the identified collaboration dimensions and corresponding control mechanisms were presented and discussed by the interviewees (Appendix E). In addressing these problematic issues, a conceptual governance framework is presented and will be discussed in this chapter.

5.2 Exploratory Study - Interviews

A governance structure is needed to support the adoption of BIM in the construction industry; therefore, to understand the contextual issues that engender collaboration in practice, a qualitative line of inquiry was undertaken. The research approach – an interpretivist approach based on semi-structured interviews was presented and discussed in chapter 3. The flexibility of this approach has actively contributed towards obtaining feedback from key protagonists to form a grounded understanding about integration, collaboration and exchange of information challenges (Rudestam & Newton, 2014). The steps, as reported by Oates (2006) for carrying out the preparation of semi-structured interviews were implemented. Accordingly, a semi-structured interview guide was prepared based on which all interviews were conducted (Appendix A).

The outcome helped in providing valuable insights to develop conceptual governance framework that identifies the relationships and interactions of the dimensions of collaboration required to improve the performance of BIM-enabled projects. Data collection and data analysis of the expletory study are generally described in this section

5.2.1 Data Collection of Exploratory Study

The research is non-quantitative, relying on interpretivism where semi-structured interviews were undertaken. Senior professionals from a wide spectrum of organisations across architectural, structural and engineering services design, project management, and contracting were selected to solicit views and opinions about collaboration and associated challenges. Participants were able to respond and comment on each question, discussing their ideas in an open-minded and shared environment, which accordingly led to achieve specific and meaningful feedback (Love et al., 2010).

According to Fellows and Liu (2015), it is imperative to select appropriate population to control immaterial variations, and thus avoid falling into sampling error. Accordingly, inclusion criteria were set that participants need to possess to qualify for the research (Robinson, 2014). The criteria includes experience in the construction industry, and in particular BIM-enabled projects, authors of academic papers dealt with BIM, senior-level BIM managers and government employees in charge of BIM projects. Based on the inclusion criteria attributes, a sample universe was drawn.

The sample size is another factor that influences the generalisability of the research findings, thereby determining correct sample size is essential to make inferences (Barlett et al., 2001). The data collection process started with one interview and based on referral sampling, a population of 25 respondents was achieved. A total of 25 interviews were conducted over eight months (Table 5.1). Each interview ranged from 60 to 90 minutes, with permission to digitally record them. All interviews were conducted in WA. While employing a large number of interviews supports the aim of the research, it was evident that saturation occurred and variability within the data followed similar patterns. The similarities in the respondents' feedback was sufficient to render a justly, thorough data set within 25 interviews.

Table 5. 1 Sample information of the exploratory study

Type of Organisation	Profession	Number	Work Experience	Serial Code
University	Associate Prof.	1	>15 Yrs	AP-01
Government Agency	Project M.	1	>25 Yrs	GA/PM-01
Investor	Asset M. Architect	1 4	>10 Yrs >10 Yrs	AM-01 A-01 to A04
Design Consultancy	MEP Structural Eng.	2 3	>10 Yrs >15 Yrs	MEP-01 to MEP-02 SE-01 to SE-03
Project Management Services	Project M.	4	>15 Yrs	PM-01 to PM-04
Cost Estimate Consultant	Qty. Surveyor Project M.	3 3	>10 Yrs >20 Yrs	QS-01 to QS-03 C/PM-01 to C/PM-03
Contractor	BIM M.	3	>10 Yrs	BM-01 to BM-03

The participants (i.e. interviewees) who participated in the research had between 10 and 25 years of experience in construction with considerable knowledge in BIM. All interviews were semi-structured, and the stimulus for dialogue was provided through the following questions:

- How are/were the performances of BIM-enabled projects, that you are/were involved with evaluated?
- What do you consider the shortfalls associated with BIM-enabled projects?
- What do you consider the areas where collaboration can be improved?
- What do you consider to be the challenges in implementing BIM in construction?

The interviews focused on the: (1) the current collaboration approaches and associated shortfalls; (2) directions to enhance collaboration and motivate the implementation of BIM in construction. At the start of each interview, the purpose of the study was introduced, and interviewees were requested to talk about their experience and projects where BIM was utilised.

5.2.2 Data Analysis

The data collected from the semi-structured interviews were examined rigorously to search for a pattern, relationships and identify the variables and the differences from the previous researches' findings. All interviews were tape-recorded using a recorder device. Transcription service provider was engaged to transcript all interviews, which included notes for pauses, interruption, hesitations, and the like to aid consistency of analysis. Following each interview, the editing process was implemented to check the respondent's feedback and other comments prior to the coding process. The editing process helped to bridge gaps and ensure consistency, thus achieve understandability and completeness. After this, participants were allowed to validate the data after the interviews to prevent misinterpretation (Strauss & Corbin, 1997)

NVivo (version 12) software was utilised for the textual data analysis which helped to develop data codes, manage the data and keep track of records in a methodical, thorough and attentive manner, which in turn increased the research accuracy and transparency (Bazeley & Jackson, 2013). The software accepted the word format of the transcripts and accordingly, coding commenced where extracts are put together into nodes. The coding process was effective and efficient as opposed to a copy and paste manual coding process. A matrix of categorised data against the different professions was developed and used to group the statement of respondents (Appendix C).

5.3 Research Findings

The results of this exploratory study will be presented in this section, including the existing collaboration dimensions and associated shortfalls, and the directions to alleviate challenges. Critical issues related to collaboration that this section will discuss and analyse form a basis to propose a conceptual governance framework.

5.3.1 Governance

Regular design and risk management meetings between all team members is sufficient to ensure adequate exchange of information and update of the progress, albeit project criticality and associated risks of consequential damages are considerable drivers for collaboration. In addressing this issue, a project manager from government agency (GA/PM-01) stated:

> "Design meetings on regular fashion enable actors from different engineering disciplines to exchange their technical knowledge about the design itself and to confirm progress update. Regular exchange of information helps to create shared understanding on both aspects,

> integrate knowledge to expedite work progress, and ultimately achieve the common objectives"

Education and interprofessional approach exert an important influence on collaborative behaviour to deliver fit-for-purpose final product. An associate professor (AP-01) commented:

> "I think that there is an education responsibility here, so we educate young people through universities with new technology, but the knowledge, in the industry, lies in people that have experience. At the minute, there is a big gap between those two, and something like BIM, makes that gap even bigger, because these young people come through with excitement about what it can do, and no knowledge of what can go wrong, and because these two people don't talk to each other, you end up with quite a risky situation. Therefore I think, that there is an education process that needs to go to the strategic level as well, to enable them to be able to foresee and anticipate the gaps, and be able to open the door that says (This is the world that these people are living in now and your QA processes don't work with this anymore)"

An architect from design consultancy firm (A-01) made the following comment:

> "Interprofessional education provides an opportunity to understand other professionals' area of expertise and viewpoints, and thus improve professional attitude, knowledge transfer and collaboration skills"

Participants concur that late appointment of the main contractor, i.e. post design completion expose the project to an undesirable risk of the unknown that could compromise the whole collaboration process. The risk is attributed to parties coming on board following design completion might not comprehend the design intent nor appreciate the benefits of BIM due to lack of time/cost compensation. A quantity surveyor (QS-02) commented:

> "Two-stage contract where principal contractor is appointed following the completion of design work is insufficient to ensure team integration and collaborative work. I think uncertainties between design and

> construction activities are better addressed when both design and construction teams are appointed at the same time."

The same is applicable when introducing BIM as a variation to the contract. A project manager (PM-01) stated:

> "My past involvement with BIM was on a large infrastructure project at Perth Airport for the terminal expansion, and BIM was implemented as a variation to the contractor after the execution of the contract (eight weeks after commencement), and it was administered by the contractor with a view to deliver the BIM LOD500 model at the end as part of the handover documents. The cost of this variation was estimated by Catalyst (organisation from South America), which we engaged in providing cost estimate, and we administered the variation through the contract. The contractor didn't really have much choice in accepting the variation. The project is now in dispute and under court review. The contract was signed between the contractor and the client at that time; however, the contractor by then engaged their subcontractors who then had to buy into the BIM ethos and processes. The subcontractors are of all engineering disciplines. Collaboration was very fragmented. The late issue of variation has put parties in the position where they were not across as to what happens in BIM. Parties were not geared up to administer BIM. Although the contractor accepted the variation based on the cost provided by Catalyst, the knock-on effect was in the form of the additional cost that the contractor incurred when approached subcontractors to implement BIM. Collaboration was not solid at all."

A BIM manager (BM-01) further stated as follows:

> "The contract should have stipulated the BIM requirements, and that variation provision should have been stipulated to include all parties. However, the best method to implement BIM is to involve the designer, contractor and operator to get their buy-in then build the model and then send off the documents for construction. However prior to commence construction we need to tender the design and appoint main contractor with clear BIM requirements, so when the main contractor appoints

> their subcontractor, every party is aware of BIM requirements before contract award. Such awareness makes it very easy to implement BIM. It is imperative to select all parties correctly to ensure BIM implementation."

5.3.2 Administration

All parties felt that requirements and expectations need to be stipulated expressly, and every party becomes clear about their scope of work and obligations, making sure that all stakeholders understand their commitment before signing that contract. An asset manager (AM-01) from investment organisations stated:

> "Effective communication and clear understanding of professional roles and obligations are the core competencies and fundamental prerequisite for collaboration to occur."

Culture of willingness to work together, education and professional approach once again were highlighted as main drivers to place common interest above self-interest. An assistant professor (AP-01) also commented on how education motivated collaboration and stated:

> "The project was a university environment where the library was going to be free to air. This has motivated every party to put common interest above any self-interest."

A project manager (PM-2) also commented as follows:

> "Placing common interest above personal interest needs to get the parties out of their houses into the overall office. And doing that takes more than just a fee, you've got to create an environment that those parties participate in, to achieve that. So, you take it away from your traditional construction delivery, confrontational approach, to more of a supportive, integrated, complete approach. It's a tough one to manage, because it's human management, as well as professional management, as well as task management."

5.3.3 Autonomy

All groups are of similar opinion that the adequate level of authority need to be assigned so as not to hinder the performance. The attribute there is that each contracting party is paid a certain amount of fee, so their team members are restricted to a certain limit of collaboration regime and associated decisions. They suggested that the decision-making process needs to be coordinated and structured to involve senior-level employees. A structure engineer (SE-01) commented:

> "My personal authority is limited to the technical aspect, therefore for any commercial decision, higher management approval is a must"

5.3.4 Mutuality

Generally, all participants were in agreement that the commitment to maintain shared interest among all contracting parties is mainly related to culture and how companies perceive their obligation to achieve successful completion. A structural engineer (SE-02) suggested an incentives scheme and stated:

> "The contract should always allow for an opportunity to reward the design team based on sufficient and economical design delivery, and not merely based on the percentage of construction cost."

A quantity surveyor (QS-01) also stated:

> "Rewards do not necessarily be monetary, but motivation should be in the form of promises to re-contract."

The general perspective is that team members need to unite and work together and if any party lags, assistance should be provided by others to maintain an alliance environment.

5.3.5 Trust and Reciprocity

Time is a critical factor to build trust as well as any previous experience. Meeting deadlines and achieving commitments are among the factors that help to build trust. Trust is a personal attribute; however, organisation role is important too by hiring the right people that are willing to adapt to the core values and leadership. Trust entails commitment that goes beyond the scope of work. An architect (A-02) stated:

> “Because we were taught to act as silos, we are adversaries, and we need to move away from that.”

A quantity surveyor (QS-03) corroborated with the above opinion and stated:

> “Trust has not been sensed amongst engineering disciplines because each party is looking after their self-interest. However, culture change is what they called for, and they signed off on “change culture- pave the future”

A project manager (PM-3) commented as follows:

> “Trust exists in the professional organisations, who see the benefit of keeping in contact with their peers. However, once a contract is executed and construction kicked-off, time to deal with subcontractors starts. Subcontractors are parochial, so they probably open to collaborate and trust other team members if they are making a profit on the project”

In each of the five dimensions that were examined, agreement within participants is noted regardless of the professional trade and size of companies representing them, albeit with some exceptions in opinions that fall outside the majority. All participants demonstrated a similar understanding as to how they perceived the issue of governance in the sense that communication via regular progress and risk management meetings facilitate achieving collaboration to the level that BIM requires. The impact of communication governance, however, is dependent on implementing BIM right from the design concept and not at any later stage. Besides, all participants concur that compensation for consequential damage if stipulated in the contract correctly would have serious impact on collaboration between parties. All participants acknowledged that contracting parties seem to exhaust efforts to collaborate to avoid undesirable consequences when the project is critical, which, in turn, substantiates any attempt to change the view on the consequential damage provision and associated rate and recovery process in the contract. However, based on the response from all participants, it can be asserted that all other collaboration dimensions require culture, awareness and professional approach that the construction industry needs to develop and maintain in the future.

5.4 Conceptual Model

The outcome of the semi-structured interviews endorsed previous research work pertinent to the uncertainty about the contractual and legal policies implications of BIM (Chao-Duivis, 2009), and factors affecting BIM adoption such as software compatibility and reliability, adversarial teams and resistance to change (Howard & Björk, 2008). Participants agreed that social-organisational and technical challenges impact the full deployment of BIM (Rezgui & Miles, 2011); however, the issue of who owns and maintain the BIM model and associated data throughout the project lifecycle remains questionable (Eastman et al., 2011).

The discussion shed light on information sharing and management from the socio-technical perspective within the collaboration context. The following sections reflect the discussion findings which have formed the outlines of information governance structure:-

5.4.1 Collaboration and Information Sharing Challenges

In BIM-enabled project, stakeholders produce different types of information. Multiple silos of information requires integration across organisations and collaboration platform that team members can access to transfer information from design to construction and reproduce in operation and maintenance to reduce asset cost. The scale and volume of information determine the process that is required to integrate such information in one document management system. Such understanding was supported by a project manager from a government agency (PM-01) who stated:

> "Managing information properly facilitate better-informed capital and operational expenditure decisions."

Organisations aim to reduce risks associated with projects. This includes minimising rework and unplanned failure, hence reducing cost and improving service levels to internal and external stakeholders. Therefore it is imperative to create common data environment to integrate the different sources of information to prevent various versions and hence ensure consistency across project lifecycle. However common data management is faced with challenges. An MEP engineer (MEP-01) from a design consultancy stated:

> ”As a statement of fact based on experience; Teambinder or an Aconex won’t manage data alone, technology and people with skills, knowledge and experience are needed to work according to a process to achieve the end goal.”

The lack of legal instrument to determine who owns the data and the ambiguity about the employer’s information requirements is another challenging issue. There was an overall agreement that common data environment is required; however, mandating it will be an inhibitor to innovation. Organisations need to provide information that is backwards and forwards compatible, can be stored in an open format and to comply with standards that are relative to the project.

5.4.2 Technology: Information Accessibility, Design and Administration

Well-structured information governance framework requires technology that is equipment and systems. Such technology is imperative for the process of communication development and to keep track of information. A project manager (PM-04) commented that:

> “I think the challenge with technology, is understanding what you are going to use it for, and not getting excited about the presentation, the sales of it”

An architect (A-03) pointed out:

> “Virtual reality and augmentative reality form a big part of what we think going forward will play a key role.”

The project manager from government agency (PM-01) argued that:

> ”It is not about understanding the technology but about how you use the information. We need to have accurate data for people that go out on track and make changes to the assets. It will make our railways safer and far more efficient. The technology and the ability to get the information enables a person to sit behind a computer taking real action based upon real-time data and information.”

The above statement was corroborated by MEP engineer (MEP-02) who commented:

> “There should be no confusion around the information delivered by digital work package and must be translated into the eventual asset management.”

There was an agreement that incomplete or incorrect information conveyed through BIM model results in most cases in a considerable amount of time spent to complete the model and liability as to the correctness of information transferred. Practitioners need to catch up with the fast development of technology and utilise it properly for better achievement (Shen et al., 2010).

5.4.3 Collaboration and Digital Engineering

The implementation of BIM requires dramatic change in the construction industry. Creating and reuse of digital information throughout the project’s lifecycle facilitates better decision making in an accurate and fully integrated collaboration and communication processes (Mihindu & Arayici, 2008). A BIM manager (BM-02) stated that:

> “Other than the 3D model, the program as fourth dimension and cost as the fifth dimension, we are now looking at the sixth dimension which is integrating quality and cost aspects. Digital engineering drives collaboration through those various dimensions and benefits in production, safety, quality and cost are to be seen.”

A project manager from the contractor side (C/PM-01) corroborated with the above statement and commented as follows:

> “Digital engineering ensures the free flow of information and the democratisation of information’s mindset, which in turn a significant gain.”

The participant from government agency (GA/PM-01) further commented:

> “Digital engineering provides the one source of truth; however, it has to be a partnership; otherwise, contractors turn off digital engineering when it’s given to them. The supply chain and particularly the sub-contractors have to see the benefit of it”

There was an overall agreement that integrated data environment improve productivity and result in better design through faster and more effective processes.

5.4.4 Collaboration and Socio Organisational Factor

Following the discussion on technology and information sharing process, the issue of organisation role and cultural change (Gu & London, 2010) in the construction industry was raised. There was an overall consensus that traditional collaboration process need to be re-engineered, and that education and training are key enablers for better implementation of BIM. An architect (A-04) stated,

> "Education is a key area for us, and it's not only education of our staff, but it's also education of our clients and what our clients can expect".

Another participant, contract administrator (QS-02) stated:

> "Everything comes back to education, its people not understanding how to take the technology and being stuck in the mindset of that I have always done it this way and it's always been ok, why do I have to change?"

The same was corroborated by a project manager (GA/PM-01) from a government agency who said:

> "BIM can be a sledgehammer to crack a nut; however, the biggest challenge is to know what we need. Clients need to be educated and knowledgeable enough."

The organisation's role is essential to create a culture of collaboration. Contracting parties are adversaries working in silos which is culture that need to be moved away from.

5.4.5 Collaboration and BIM-Related Standards

The standards and regulations in BIM-based projects is another section that the research has investigated. Participants across the disciplines relatively shared the view that clients are the industry mandate. A BIM manager (BM-02) pointed out that:

> ”Mandate that says ‘thou shalt’ is not required but standards in the form of general guidelines and general principles are enough to initiate the pressure.”

The above statement was corroborated by a project manager (PM-01) who said:

> “We have got the benefits of being driven from the top, but I don’t see the need to wait on government to mandate that.”

The above feedback supports the opinion that standards promote the integration and collaboration that BIM requires. The paper-based standards for information management and smart asset management such as the Publically Available Specifications (PAS 1192 Parts 2, 3, 4 and 5) give an overview of the issues around creating asset information, managing and sharing it between project parties. Data exchange standards such as IFC (industry foundation classes) has resolved the interoperability across the multiple file-formats albeit the associated risk of data loss when transferring BIM model into IFC. Serror et al. (2008) defines IFC as “IFC is an evolving international information exchange standard that allows project participants to work across different software applications with data continuity.” (p.774)

Industry practitioners find IFC suitable for vertical built environment while Serror et al. (2008) identify the adoption level of IFC as relatively low. The Construction Operations Building Information Exchange (COBie) presents an excel spreadsheet format which offers practical method for sharing BIM data during design and construction and handover of data into operation and management (East, 2007), however, requires substantial input from team members into the spreadsheet and hence time and cost implications. The standards’ ability to facilitate collaboration remain limited dependent on individuals’ willingness to adopt them as an aspect of governance without the need for any obligatory rules.

The interviews converged to identify information governing as unregulated and carried out based on an ad-hoc way. Companies appear to develop a data management strategy on a project basis and in alignment with the client’s requirements on each project. Therefore communication protocol embedded within governance framework is imperative to track information and achieve collaborative

BIM solution. Such a framework should ensure the right to access BIM related information underpinned with legal agreements to address the risk of liability while in a collaborative environment. In addition, participants need to understand their roles and responsibilities (Holzer, 2007) for appropriate delivery of collaboration requirements.

There was a consensus that the quality of information is just as important as the quality of any other construction work. The single source of truth resides in a common data environment that all participants should have access to subject to appropriate security. Project team need to understand the information requirements and the aimed use of it. This was best clarified by the project manager from government agency (GA/PM-01) who commented:

> "The project information model and its requirements are critical that we need to understand what is required at each stage. There are various applications such as SAD for cost control, ARM for risk management and Primavera for scheduling that are hard to link together; therefore we pull the information out from each application and use the concept of master data management to be able to report on the progress. This requires understanding the DNA nature of information that drives the decision making".

5.5 Conceptual Governance Framework

The socio-organisational, technical and legal challenges have so far hindered the full implementation of BIM (Won et al., 2013). Cao et al. (2015) clarify that technology and provision of correct information have a major impact on team collaboration and hence the overall project's outcome. (Sacks et al., 2018) assert that the development of reliable communication protocols and stipulating roles and responsibilities among participants are required to overcome BIM adoption shortcomings

The semi-structured interviews with industry professionals converged to consensus about the education and training as major enablers to address the socio-organisational limitations and identified serious requirements to create a governance framework and controlled communication flow. Such framework need to be underpinned by a collaboration platform to alleviate BIM implementation challenges. This research introduces conceptual governance framework and identifies people, collaboration process and technology as the main dimensions of the framework within a collaborative environment (Figure 5.1).

The proposed framework (Figure 5.2) starts with identifying the conceptualisation of asset information that need to be collected throughout the planned project run time. Different types of information in 3D models, business documents and others are provided by team members, stored in common data environment in various formats and re-used by the team members at different times. Accordingly enabling access to all team members and often complex information can be captured and modelled, which in turn alleviate security concerns, information ownership and liability that are usually the challenges in BIM related construction industry.

Following the interviews, an architect (A-02) has debated the security concern when a participant accessing some sensitive information and commented:

> "I expect the system to recognise the user and provide the relevant information only so that a CAD technician, for example, should not be granted access to a detailed cost plan."

Another participant, structural engineer (SE-03) argued that:

> "From efficiency perspective, if I am an engineer need to carry out a particular task, I don't want to navigate through a massive folder structure of files and data to allocate the piece of information that I need but expect the system to show me that information that is relevant to me on that phase of the project."

These comments were corroborated by other participants from contracting company and project management consultant. By and large, there was an overall agreement that the common data environment of the proposed framework must ensure that the right participants have access to the right information at the right time. In order to achieve this, the concept of common data environment is introduced to the governance framework. Rigorous access control is assigned to each or group of team members based on corresponding engineering discipline, roles and responsibilities. Accordingly, the overall framework regulates authority to view, amend, create and delete information and monitor work progress. Therefore ensure availability of correct information, confidentiality and protection of intellectual property hence safe environment for integration and collaboration with less exposure to errors.

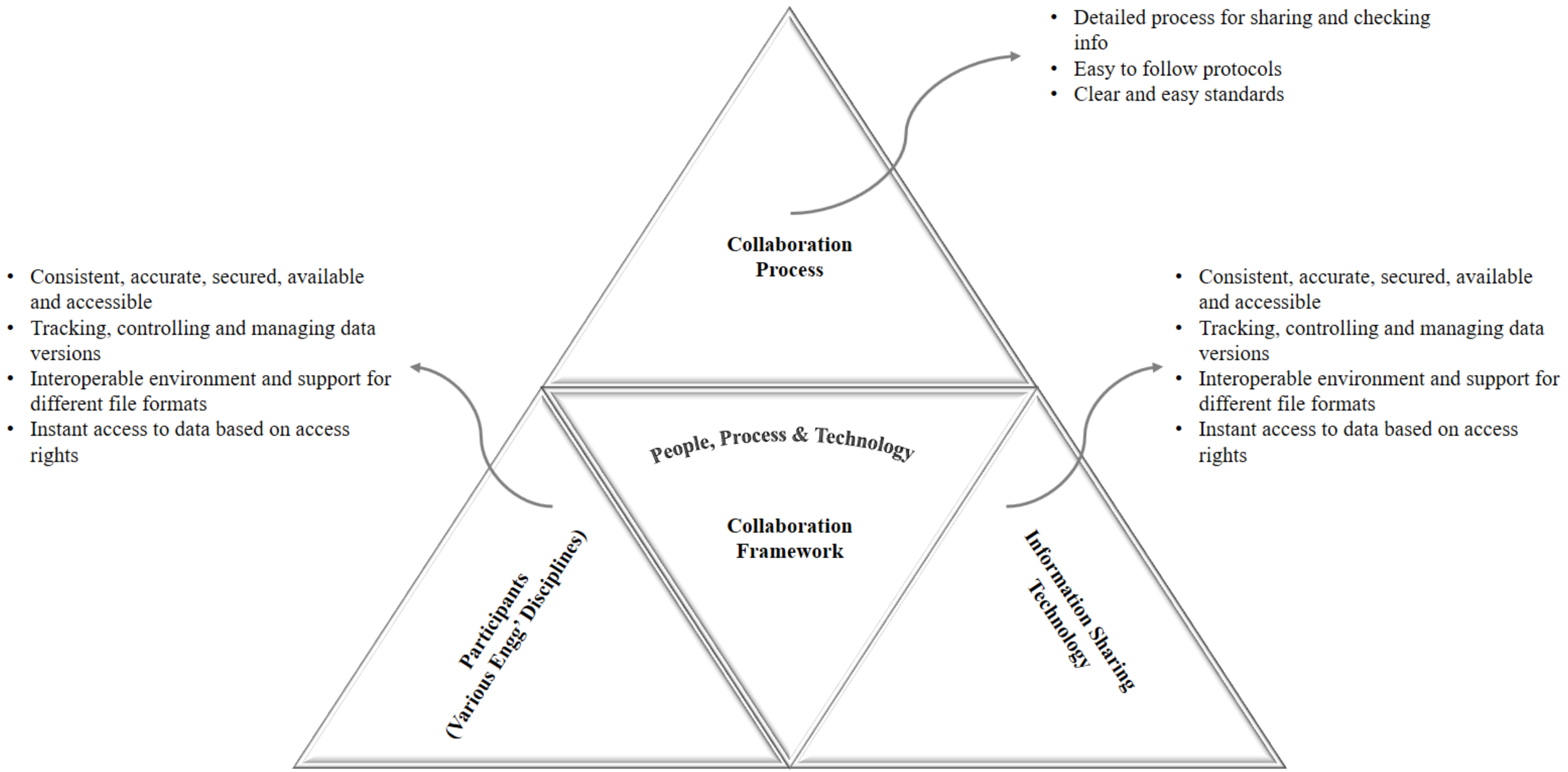


Figure 5. 1 Governance framework dimensions

5.5.1 Key Characteristics and Relationship between Entities

According to the interviews feedback, each engineering discipline has their work in progress (WIP) area where information is safe, secure and access is limited to the author only. Upon completion of WIP stages, participants of all disciplines transmit their information into sharing zone, which enables multi-geographically spaces design and construction teams (across organisational and geographical boundaries) to access their information when they need it. Teams work together on the same information via a collaborative approach for authoring and information become easy to find and validate, which in turn increase efficiency and productivity. Design work evolve through a series of alterations until it completes and ultimate design model become ready for publishing.

Once the federated design model is published, participants who have not been part of the design process such as contractors will be granted access to that information with no authority to change and thus ownership remains with the originators. The said information is marked with status code to recognise the approved from the under review version and corresponding metadata, which can be used for construction. Following project handover, all information will be transferred into archived zone where it kept for future use

Design work evolve through a series of alterations until it completes and ultimate design model become ready for publishing. Once the federated design model is published, project parties who have not been part of the design process such as contractors will be granted access to that information with no authority to change, and thus ownership remains with the originators. The said information is marked with status code to recognise the approved from the under review version and corresponding metadata, which can be used for construction. Following project handover, all information will be transferred into archived zone where it kept for future use.

The common data environment of the proposed model considers files interoperability for information viewing and versioning. Access for multi-users is enabled for eventual BIM data integration. Information models of various engineering disciplines are combined following quality control process to ensure models' completeness and correctness of data. Information versioning to track changes and work progress is considered which based on the consultation with BIM experts, appear to be very useful utility.

5.5.2 Main Dimensions and Associated Variables

The foregoing observations and results from the semi-structured interviews confirm that the ignorance of supply chain collaboration philosophy need to be addressed. Successful implementation of collaboration in the construction industry is faced with a challenging traditional culture that is developed based on adversarial relationships and personal interests. Transition into shared culture that exceeds organisations' boundaries based on trust and common interest is what need to be implemented. Therefore information technology solutions alone do not result in good collaboration unless associated organisational and people issues are resolved (Faniran et al., 2001; Ferneley et al., 2003) . Similarly, benefits derived from the use of technology will not be reaped with exclusive focus on organisational and cultural issues, but a delicate balance is required (Eseryel et al., 2002).

In order to achieve the research objectives, the proposed framework for effective collaboration considers that the three main dimensions of socio-organisational aspects, process of information and technological tools are adopted and combined based on common standards that ensures balanced harmonisation. The data collected from the semi-structured interviews went through rigorous development, analysed and synthesised and eventually used to determine the sequence of the main categories based on their importance level. The people and socio-organisational aspect ranks first in priority level followed by processes and procedures and lastly the technology aspect.

The variables associated with each dimension are of an important influence to the success of collaborative work. Figure 5.3 illustrates the proposed framework main dimensions and associated variables.

5.6 Chapter Summary

Collaborative work is a complex phenomenon. Multiple components and associated variables impact collaboration. The importance of each variable and the interaction between them vary throughout the process lifecycle. Enablers of collaboration such as trust, skills and competency, education and awareness, teamwork culture normally limit the influence of collaboration inhibitors. However, collaboration effectiveness is contingent on technology and effective communication tools that project parties implement.

An extensive research about collaboration barriers has been undertaken during the last two decades; however, limited empirical research-based studies have been conducted to examine the governance structures needed to support the adoption of BIM in construction. Therefore, an expletory study to empirically interpret and understand the relationships and interactions of the dimensions of collaboration required to improve the performance of BIM-enabled projects was presented in this chapter.

A qualitative line of inquiry that relies on key informant interviews has been applied for this study. A total of 25 semi-structured interviews were conducted with construction practitioners who had been involved in BIM-enabled projects across Australia. A governance-based framework was identified with a widespread consensus among the participants that; establishing reliable communication channels supported by contractual control procedures is needed to ensure that all parties are performing effectively; cascading down from initiation to handover under collaborative framework.

The exploratory study presented in this chapter is significant for the research. This is because the proposed conceptual governance framework has enabled an opportunity for further research activities towards understanding the impact of collaboration challenges on BIM procurement methods. The outcomes of this chapter identified the gaps in the contractual implications of BIM deployment and helped the researcher to undertake further legal investigations that will be presented in the following chapter.

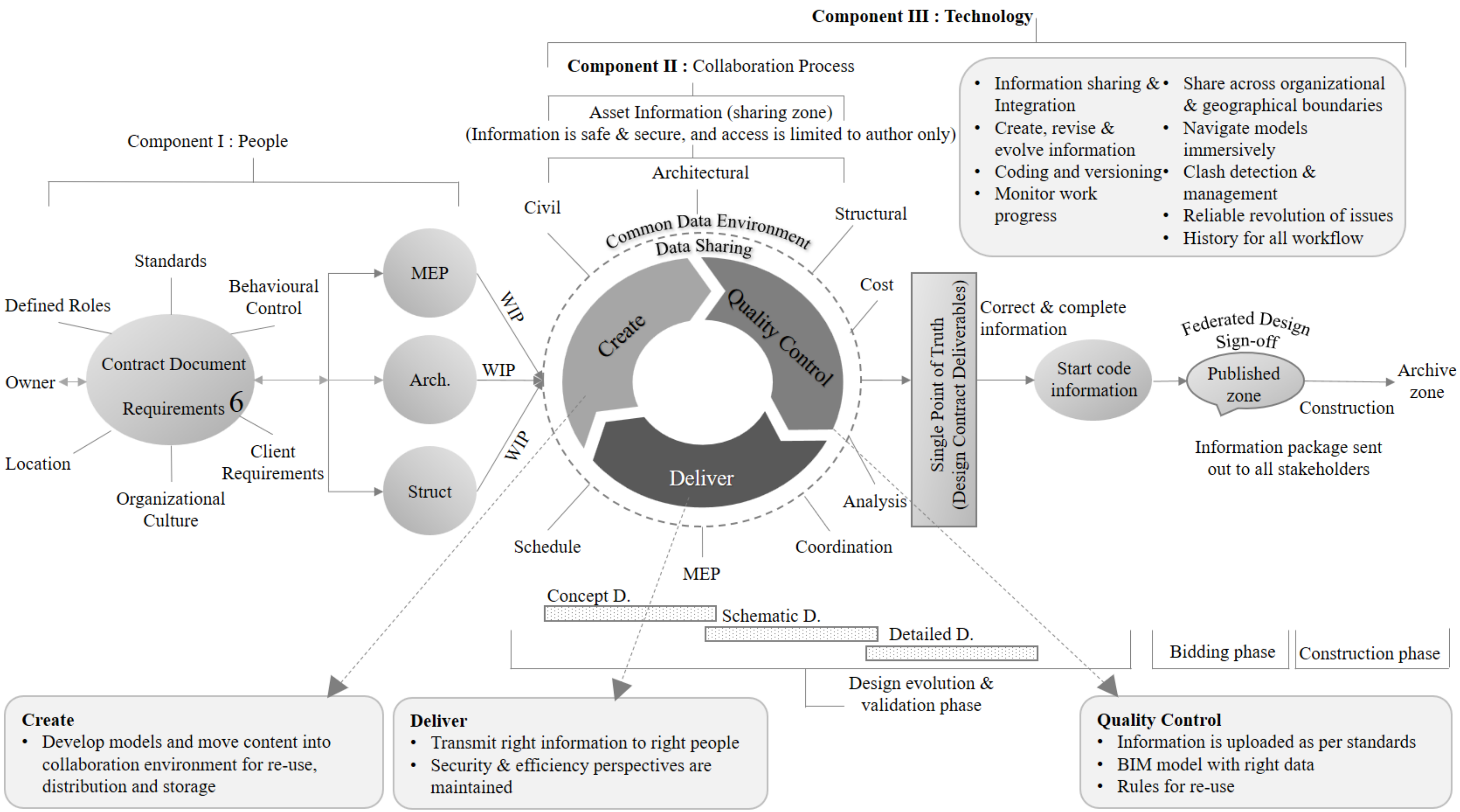


Figure 5. 2 Conceptual governance framework

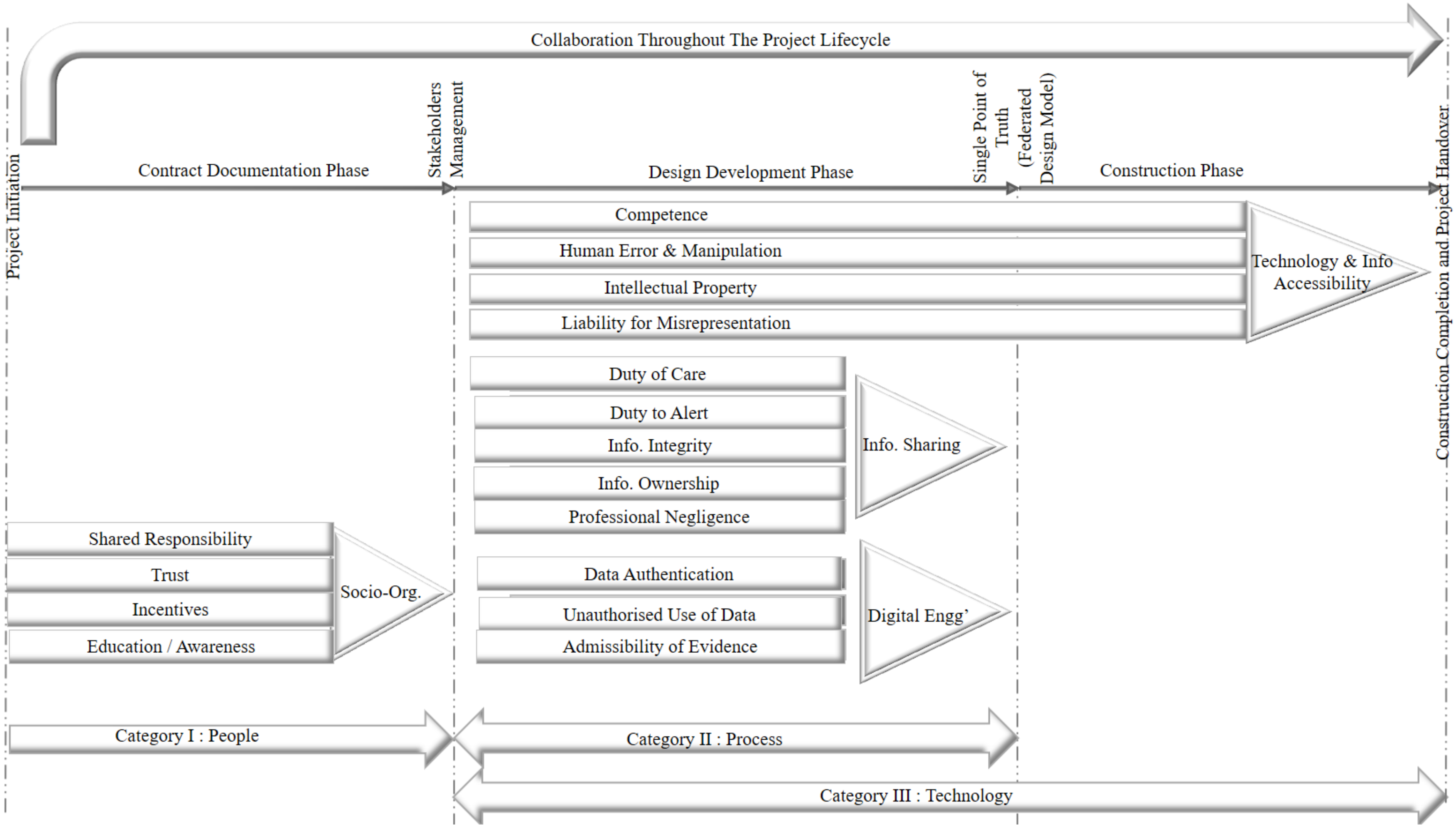


Figure 5. 3 Conceptual governance framework: dimensions and associated variable

CHAPTER 6 CASE LAW

6.1 Chapter Introduction

In chapter 5, a conceptual framework derived from the qualitative exploratory research was presented. The proposed framework illustrates the collaboration that contracting parties need to yield in BIM-enabled project to achieve the intended objectives. The main dimensions and associated variables were analysed in this chapter to evaluate the impact on the collaboration between parties and hence demonstrate the validity of the framework in the construction industry. The validity of the proposed framework has involved reviewing voluminous precedent case laws and court judgments to test for relevancy and reliability and in turn, strengthen the argument.

The complexity of each variable is discussed in this chapter with reference to precedent case-laws in areas of technology, communication and information processes and team management to understand how they interact with complex processes. Whether these factors are collaboration enablers or inhibitors is contingent on how the contracting parties opt to support and implement them. The key findings are listed in Table 6.2, which evaluate how collaboration variables affect the organisations involved in the project's construction process and hence the future success of collaboration in BIM-enabled projects. The impact of collaboration variables makes the consistency of the proposed framework reliable and promotes the possibility for successful adoption in the construction industry.

6.2 Proposed Governance Framework

The collaboration governance framework that was conceptualised from the exploratory interviews and the prerequisite variables have been legitimised using precedents from case-laws and court judgments. The interrelation between the framework core dimensions and associated variables is shown in Table 6.1

Table 6. 1 Governance-based framework - prerequisite variables

	Main Category	Group	Associated Factor
Collaboration Process	People	- Socio Organisational and People Issues	• Shared responsibility
			• Trust and reciprocity
			• Incentives
			• Education and awareness
	Process	- Information Sharing	• Duty of care
			• Duty to alert
			• Information integrity
			• Information ownership
			• Professional negligence
		- Digital Engineering	• Admissibility of evidence
			• Data authentication
			• Unauthorized use of data by others
	Technology	- Technology, Information Accessibility (Design and Administration)	• Human error and manipulation
			• Competency
			• Intellectual property
			• Liability for misrepresentation

6.2.1 First Component: People

The ability to generate new innovative ideas enables organisations to meet market demands which control their success (Howkins, 2001). As a result, a new set of rules and values are needed to link organisations on organisational level (example abandon the hierarchical structure and implement networked cross-functional teams).

BIM is an emerging technology that requires organisations to focus on intangible resources such as information/knowledge and collaborative relationships. Skills and resources have become essential to competitive success; therefore, strategic partnerships and collaboration across organisational boundaries are no more an option but a necessity. However, organisational adaptability to the required collaborative scenarios are faced with socio-organisational variables which are discussed below:

- Shared Responsibilities

Collective responsibility enables group efforts to succeed despite unforeseen complications (Scardamalia, 2002). As described in Table 6.2, courts when it comes to works that are associated with risk to undertake, tend to rule in favour of shared liability. In addition to shared liability, negotiation to decide on an omission dispute is enforced.

The judgments tendency gives rise to collaboration through integration as opposed to single end of responsibility. In the case of *National Museums and Galleries on Merseyside Board of Trustees vs AEW Architects and Designers Ltd* (2013), the design of steps, seats and terraces was the responsibility of the AEW whom in turn engaged a contractor "PGT" to construct the work with certain extent of design responsibility. Although AEW was liable to provide the requisite design criteria to enable PGT to design effectively, both parties were held liable for the design omission in different contribution. Court held AEW liable for failure to exercise reasonable care and skill, and PGT liable for failure to put forward fit-for-purpose proposals in respect to seats and steps.

The acknowledgement of shared liability by the legal system motivates parties to communicate more freely about various issues, provides incentives to improve project outcomes and efficiencies, facilitates room for innovation and reduces the likelihood of additional costs arising out of disputes.

- Trust and Reciprocity

Tyler (1996) recognises trust as a major issue in the construction industry; the starting point for problem-solving sessions across contracting parties; and a means of facilitating high-tech industry growth and success. Trust is viewed as emerging through a variety of mechanisms; however, can be influenced by increasing perceived similarities and the number of positive exchanges. Organisations have viewed the cost and benefits of trust and distrust in terms of control cost, and it appeared that although promoting trust is costly in that it requires time to establish, the lack of trust is costlier (Thomas & Bostrom, 2010). Cooperative actions give rise to a sense of obligations, and so create the fabric of an embedding atmosphere of trust.

Das and Teng (2004) clarify that relationships and obligations between individuals are defined through contracts and agreements, which are regarded as another attribute of system-based trust because of their ability to reduce uncertainties, minimise, share or shift risks among contracting parties. Contracts and agreements explicate implicit expectations and make obligations and rights visible, and accordingly contribute to fair risk allocation, overall project performance improvement and costs reduction (Kadefors, 2004; Kramer, 1999)

Courts placed an implied duty on contracting parties to cooperate and to implement good faith in resolving disputes and achieving the project's objectives. Obligations even if implied, motivate parties to adapt to a new environment, new technologies and new ways of working as a means of enhancing team understanding and accelerating intra-group bonding. The court of appeal of New Zealand in the case of *Peters (WA) Ltd vs. Petersville Ltd* (2001) stated that consensus is the essence of the contract, and that for a contract to be enforceable, consensus or at least subjective means of sufficient certainty on all essential terms must have been reached between parties.

The concept of good faith in the case of *Strzelecki Holdings Pty Ltd vs. Cable Sands Pty Ltd* (2010) is regarded as precluding bad faith, and it was said:

"Good faith conduct is the guide to the manner in which the parties should pursue their mutual contractual objectives. Such conduct is breached when a party acts in "bad faith" - a conduct that is contrary to community standards of honesty, reasonableness or fairness." (p.34)

Therefore the implied term to cooperate is the generally accepted position in law

- Incentives

Turner and Simister (2001) argue that contracting parties ought to be motivated to achieve project objectives, and therefore it is essential to apply contractual incentives (and disincentives). Bower et al. (2002) assert that incentives result in many benefits such as improved cost, quality and schedule performance, and clarify that incorporating cost incentives into the project's payment mechanism, motivates the contracting parties to work together to reduce (or cap) the outturn cost of the project. Joint decision making (problem-solving, joint risk and opportunity planning and management) are encouraged by strategies that fall in between these two poles – i.e., involving some significant sharing of risks and rewards. Accordingly, the motives of contracting parties are aligned and efforts are targeted towards achieving project objectives (Turner, 2004). Performance incentives tied to the achievement specific performance targets are also considered to align the goals of contracting parties with project objectives (Hughes et al., 2007).

It is evident that fair risk sharing encourages cooperative interaction; therefore the proposed conceptual model considers incentives to motivate information sharing and hence encourage collaboration.

- Education and Awareness

Organisations need to establish a structure that supports information management and knowledge sharing. Norms and trust mechanisms form a critical part of such structure (Sanchez & Mahoney, 1996). Behaviour and culture represent another crucial element that often had unintended consequences of inhibiting collaboration and sharing of knowledge across organisational boundaries. The culture that promotes individualistic behaviour in which functions are rewarded for hoarding information can inhibit effective knowledge management (O'dell & Grayson, 1998).

Corporate vision is needed to generate a clear organisational purpose and prompt the necessary changes in the organisation so that it can achieve its desired goals. Through an articulated and communicated vision, a sense of involvement and contribution among parties should be engendered (Maier & Hadrich, 2011). In essence, it is important that organisational structures be designed for flexibility (as opposed to rigidity) so that they encourage sharing and collaboration across boundaries within the organisation and across the supply chain.

Shaping culture through education and awareness is central in a firm’s ability to manage its knowledge and for the creation of new ideas (Yew Wong, 2005). As discussed earlier, incentives and rewards contribute to an effective knowledge management activities. Incentive systems motivate parties to take time to generate knowledge (i.e. learn), share their knowledge and help others outside their divisions or functions, hence effective collaboration. A structure that stipulates functional responsibilities and authorities for team members, and define the various tasks, processes and policies is the principal focus of the proposed conceptual framework.

6.2.2 Second Component: Process

The quality of decision making controls, to a large extent, the success or failure of an organisation. An optimal decision making is facilitated through a system and process that allow collaboration within and between organisations, in a negotiated, as opposed to coercive environment. There is compelling evidence suggests that enhancing mutual benefits and improving overall performance are achieved through a process that involves developing a workflow to share, execute, monitor and modify the information (Doukidis et al., 2007). Collaboration System and Process variables are as follows:

- Duty of Care

Courts apply the neighbour principle as general criteria for when a duty of care would exist. In the case of *Donoghue vs. Stevenson* (1930), Lord Atkins stated that "You must take reasonable care to avoid acts or omissions which you can reasonably foresee would be likely to injure your neighbour". (p.2)

The neighbour refers to persons who are so closely and directly affected by the act that any reasonable person ought to have them in contemplation as being so affected when that person is directing their mind to the acts or omissions which are called in question. Case law and the common law principles have established that there are several factual situations in which a duty of care is known to be owned. For example, designers owe duty of care to owners and to the building occupiers. The duty of care in providing professional design services extends to principle architects and engineering services designers even when they do not build the project or exercise ultimate control over construction (see case *Residential Community Assn vs Skidmore, Owings and Merrill LLP*, 2014). The Court of Appeal concluded that design professional owes a duty of care to future homeowners.

The proposed conceptual framework relies on the fact that duty of care in BIM-enabled project is reasonably foreseeable, which in turn motivates all parties to collaborate to ensure the delivery of above the reasonable standard of care deign.

- Duty to Alert

In the case of *Beshada v. Johns-Manville Prods. Corp*. (1982), Court concluded that claim of strict liability for failure to warn is not supported and that knowledge, even scientifically undiscovered knowledge, is imputed under strict liability, therefore could no longer be raised as a defence in any such action. Case law judgments review the issue of foreseeability in the strict liability context and argue that it is necessary to retain the foreseeability requirement concerning duty-to-warn cases to fulfil the function that the risk/utility analysis serves in design defect cases. The judgment of the Supreme Court of Virginia in the case of *Virginia Military Institute vs King* (1977) held the architects liable to report any serious problem with the design before construction was completed if they reasonably should have known of the problem.

Detailed design package is the ultimate product in a BIM-enabled project which should be reasonably fit and suitable for the intended purpose and too safe once constructed for anyone come in contact with otherwise designers shall be liable for the resultant damages. The proposed conceptual framework refers to such case law development to motivate all parties to work collectively and report any incident of safety concern.

- Information Integrity

In any project, information assets enable project parties to achieve their intended objectives. Therefore it is imperative to store, process project information in real-time and communicate it between all stakeholders in digital format via reliable information systems. While the emerging technologies facilitate the required information systems, such technologies are prone to error (Ash et al., 2004), which in turn could increase the limit of uncertainty and hence compromise decisions made in real-time based on real-time information. Therefore auditing procedures and internal controls have become paramount to ensure information and data retain their integrity. Organisations have fiduciary duty of utmost care to verify the accuracy of their information (see case *Horiike vs Coldwell Banker Residential Brokerage Co*, 2016) and to protect their digital information assets.

In the case of *Cobell v. Babbitt* (1999), the plaintiffs filed a lawsuit to force the government of USA to abide by its duty to render an accurate accounting of the money currently held within the Individual Indian Money (IIM) trust. The court held that the United States government, under the actions of defendants and their predecessors, is currently in breach of certain trust duties owed to plaintiffs.

(Boritz, 2004) suggests that information integrity remain intact when the processing methods, accuracy and validity of information are safeguarded. This means that both input data and the processes to produce information need to be protected. The proposed conceptual framework relies on internal controls of coding and versioning and access level to ensure information integrity.

- Information Ownership

The basic principle behind copyright protection is the concept that an author should have the right to exploit their work through reproduction without others being allowed to copy the creative output. In Australian law, copyright has been seen very much as an economic right, focusing on the protection of commercial activities designed to exploit works for profit (Landes & Posner, 1989). However work to be protected by copyright must be expressed in a material form, and that mere ideas or information will not be protected unless expressed and preserved in some way. The defendant in the case of *Digital Communications Associates Inc vs SoftKlone Distribution Corp,* (1987) copied the status screen function from a computer program developed by a competitor and claimed that the function in question lists the information required from users prior to put the main program into effect. The defendant argued that such function was not the subject matter of copyright protection. The court rejected the defendant's analysis and held that the status screen involves considerable stylistic creativity and authorship beyond the ideas embodied in the status screen.

In the case of *Computer Edge Pty ltd vs Apple Computer Inc* (1986), the high court refused copyright protection to computer programs which could not be classified as any work or subject matter. However post Apple's case, literary work has been amended to accommodate computer technology protection to principles of copyright law (see case *Data Access Corp vs Powerflex .Services Pty Ltd,* 1999). Courts also recognise the person who supplies the requisite efforts to create the work as the originator who is, prima facia, the first owner of any copyright. The majority of Lords in the case of *Walter vs Lane* (1900), agreed that a reporter who took down speeches in shorthand and then transcribed them to be published verbatim has indeed exercised enough efforts to be the author of copyright works.

The proposed conceptual framework relies on an information-sharing culture based on communication flow between participants. The law provides sufficient protection for all participants to share their information and develop the final design model.

- Professional Negligence

The Architect who is expert in the architecture designs of interior spaces and exterior masses, and the Engineer who designs and supervises all other engineering services are both liable for their errors and any negligent designs; and that the distinguishing characteristics of both professions have no bearing on liability (see cases Cowles vs City of Minneapolis, 1915; Peterson vs Rawson, 1857).

Unsafe structure endangers not only the owner but any third party who may come in contact with the structure. The right of these third parties should not be subject to the agreement between the architect and the owner. In one of the unusual decisions reached in the case of *Sherman vs Miller Construction Co.* (1927), a child was injured at school when he fell off a wall which contained no guard rail. The suit was brought against the architect but was dismissed on the ground that the school board has approved the plans prepared by the architect. However such concept has changed, and an architect should not be privileged to design a building which creates unreasonable risks of injuries to third parties and defend his action on the ground that this is the best the owner could afford or that the building was in accordance with the owner's wishes.

In the case of *Drexel Institute of Technology vs Boulware*, (1954) the court of Common Pleas, First Judicial District of Pennsylvania expressly ruled that that the owner's approval of the plans and specifications didn't relieve the architect of his responsibility for a faulty design. Similar decision was held in the case of *Barraque vs Neff* (1942). A rule of law that would force the architect to prepare plans for a safe building would still leave the architect the privilege to refuse to prepare plans for an inadequate structure, thereby eliminating liability on his part. Courts also hold both architects and engineers liable for their design omissions.

In the case of *Bayshore Development Company vs Bonfoey* (1918), the owner sued the architect for damages on the ground that the completed building was not waterproof. The court recognised the liability of the architect under such circumstances and held that the measure of damages was an amount equal to the difference between the value of the building as actually designed and constructed and the value it would have been if it had been properly designed and constructed.

The American Institute of Architects (AIA Doc. No. B-121) under standard form of agreement between owner and architect, condition 7, provides that the architect or engineer shall superintend the erection of the structure in accordance with the plans and specifications. Therefore the architect becomes liable to prevent the structure from being erected so that it will contain a material variation from the plans and specifications. In the case of *Day vs National-U.S. Radiator Corp*. (1559), the Judicial District Court in Louisiana stated that architect is appointed to superintend the work are supposed to snoop, pry and prod. Further to this court also held that supervisor owes to workmen a duty of using due care and that a workman injured as a result of careless supervision is entitled to recover from the architect (see case *Clemens vs Benzinger,*1925).

Certifying partial payment accurately is another obligation that the architect and all other design engineers hold. The contract in *Corey vs Eastman* (1896) provided for partial payments as the work progressed. The contractor secured a certificate from the architect that more than the amount of work necessary for the first payment had been completed, and shortly thereafter the builder went into insolvency. It was shown that the certificate was carelessly made and the owner sought to recover the damage sustained.

A misrepresentation as to the cost of a proposed building should result in liability to the architect. In the case of *Lain vs School District* (1950), the architect was hired to deliver a design for a building not to exceed a stated dollar cost; however actual construction cost exceeded the stated cost and court held that architect is not entitled to recover his fees due to his failure to comply.

Law is strict about the negligence liability which in turn motivates all parties to ensure the delivery of a compliant design and render sufficient supervision services. The proposed conceptual framework obligates all parties to contractual clauses that stipulate their legal duty. It also identifies participants' inputs and tracks design changes throughout the process which facilitates the detection of design defects, therefore motivate parties to work together collaboratively.

- Admissibility of Evidence

A contract is a legally binding agreement between two or more entities (Carter et al., 1996), and once signed then parties are deemed to have read and accepted the terms set out in it (see case *L'Estrange vs Graucob,* 1934). However, most modern contracts are effected via some personal interaction and to overcome the lack of face to face involvement (Passera & Haapio, 2013), it is necessary to rely on identity authentication mechanisms such as digital signatures technology.

In the case of *Lorraine vs Markel Am. Ins. Co.* (2007), an insurance dispute over recovery of insurance proceeds after the Plaintiff's boat was struck by lightning. Both parties submitted motion for summary judgment and the submission was supported by a list of email correspondence that discussed the policy in question. Judge Grimm from District Court recognised the requirements that parties need to fulfil to get electronically stored information into evidence.

The American Bar Association Guidelines on digital signatures state that a digital signature technology can be used to maintain the integrity and authenticity of a document. Digital signature technology doesn't concern itself with confidentiality although this can be achieved by means of other cryptographic methods. In Australia, electronic signatures are recognised as having the same effect as handwritten signatures, subject to clearly identifying the identity and approval of the signor.

It is essential to maintain the integrity of a computerised record to ensure its evidential value. Data stored on a computer can easily be amended. Therefore it is necessary from an evidentiary perspective to ensure that the information stored in relation to all electronic transactions is secured and cannot be altered by anyone without detection. In the case *United States vs Safavian, 435 F. Supp. 2d 36, 41-42,* (2006), during a preliminary investigation about the admissibility of emails, government lawyers compiled statements from FBI agents to support their presentation. The trial Judge alerted that witnesses with personal knowledge of facts would be called for as opposed to rely on FBI agent's testimony merely. Meeting the threshold of relevance ensures the admissibility of evidence, unless the constitution, a statute, rule of evidence or procedure, or case law requires that it be excluded.

The proposed conceptual framework considers the legal effect that is given by law to information, records and signatures in an electronic form. Participants in BIM-enabled project become keen to maintain the evidential value of their electronic documents, enhancing the level of accuracy and reliability of their design documents prior to transmit into the collaborative platform. Security measures of password and user ID are applied to protect the data while exchanging between participants.

- Data Authentication

The widespread use of computers resulted in a limitless variety of electronic records, and subsequently, different admissibility issues related to authentication are recorded (Weinstein & Berger, 2015). Computer simulations are also treated as scientific evidence; however require authentication (see case *Commercial Union Ins. Co. vs. Boston Edison Co.*, 1992). The proof of authentication may be direct or circumstantial. The simplest (and likely most common) form of authentication is through the testimony of a witness with knowledge that a matter is what it is claimed to be. Proof of delivery to authenticate the delivery of materials at a certain time to a certain party serves as admissible proof in a court law (see cases *Bray vs. Bi-State Dev. Corp., 949 S.W.2d 93,* (1997); *Kudlacek vs. Fiat, 244 Neb. 822, 509 N.W.2d 603,* (1994)

In the case of *US vs Vayner* (2014), the defendant who was earlier convicted by the District Court of unlawful transfer "through a Gmail address" of a false identification document, submitted an appeal. The United States Court of Appeal, Second Circuit concluded that for emails and other electronic documents, delivery report is obtained which typically includes the date and time of the dispatch, the receipt's address, the transmission completion status, and sometimes the transmitted data, the number of pages delivered, and the receipt's identification information. Accordingly, it was held that the government's proof was not unassailable, and the following was stated: "The requirement of authentication is a condition precedent to admitting evidence" (p.2)

The evidentiary requirements of relevancy and authentication are required to ensure admissibility of electronic documents into evidence (see cases *United States vs Meienberg, 263 F.3d 1177, 1180,* (2001); *United States vs. Tank, 200 F.3d 627,* *630*, (2000); *United States vs. Reilly, 33 F.3d 1396, 1404,* (1994); *United States vs. Howard-Arias, 679 F.2d 363, 366,* (1982); *Telewizja Polska USA, Inc. vs. Echostar Satellite Corp., 2004 U.S. Dist. LEXIS 20845, 2004 WL 2367740,* (2004)). Thoughtful preparation is required to achieve evidence admissibility.

Technology evolves so rapidly that there is no single approach to authenticate electronic evidence. Lindblad and Vass (2015) clarify that collaborative workflow is required to facilitate the implantation of BIM in construction, which can only be accomplished through change management strategy (Vass & Gustavsson, 2017).

Based on the outcome from the exploratory study, adequate IT infrastructure is required as an integral part of BIM execution plan. Such findings are in are consistent with previously reported research outcomes (e.g., Bosch-Sijtsema et al. (2017) and Papadonikolaki et al. (2016)). The proposed conceptual framework incorporates data authentication requirements where each participant transmit their information along with a delivery report to record whatever details needed to authenticate the content of the dispatch.

- Unauthorised Use of Data

Disclosure of confidential information or re-use for a purpose beyond the contemplation of the sender is unauthorised by law and considered to be a breach of confidence. Such consideration is irrelevant whether the unauthorised access and/or use was intended or unintended. However, courts are inclined to identify the content of the alleged confidential information and corresponding purpose before making judgment. The identification of the confidential information need to be accurate and not merely global. In the case of *O'Brien v Komesaroff* (1982), the High Court of Australia could not grant protection for the alleged confidential information as there was a failure to identify which part of the information in question was not common knowledge.

The public interest is a major factor in the courts' determination when it comes to information disclosure as decided in the case of *Smith Kline & French Laboratories (Australia) Ltd vs Secretary, Department of Community Services and Health* (1991) where the appellant supplied information to the respondent pertaining to its patented chemical, cimetidine, with a view to having it approved by the respondent for importation and marketing as a treatment for stomach ulcers. The issue arose as to how far such a purpose extends where the respondent uses such information in the assessment of a generic drug by another pharmaceutical company, Alphapharm. The appellant claimed that such use is beyond the purpose for which the information was supplied and sought to restrain the respondent's use of the information for the evaluation of Alphapharm's generic version of cimetidine. The Full Court determination turned on whether the respondent's use of the information would amount to the taking of an unfair advantage of the information. In finding for the defendant, the court decided to protect the health and safety of community and public interest.

Further difficulties may arise where the receipt is working in the same field as the confider and may have prior knowledge of the subject matter sough3- t to be protected by the confider. In the case of *Johnson vs Heat & Air Systems Ltd* (1941), the defendants were able to substantiate their prior knowledge with evidence of their work.

The proposed conceptual framework accommodates the law provisions and implement the requirement to identify the confidential information. Participants become comfortable to exchange their information and work collaboratively.

6.2.3 Third Component: Technology

Information technology advancement foster inter-firm communication, and positively impact long-term relation orientation and network governance (Chae et al. (2005); Paulraj et al. (2008)). IT systems play an enabling role to facilitate information sharing and visibility, which are fundamental elements of collaboration (Klein, 2007) and (Swaminathan & Tayur, 2003). Parties involved in BIM enabled project, and with primary aim of achieving collaboration, are being required to share design and construction data. In much of the prior related literature, information pooling and visibility result in potential improvements in operational performance and increases the responsiveness to changing demands (eg., Huang and Iravani (2005); Barratt and Oke (2007); Paulraj et al. (2008))

The overall IT capability is found to be positively linked to organisation's performance with high potential of providing a significant competitive advantage (Sanders, 2007). Therefore the production of knowledge and access to it is greatly enhanced by technology (Ding et al., 2010). The variables associated with technology are discussed below:

- Human Error and Manipulation

Designing a product that overlooks human error amounts to design negligence, therefore safe to say that human error is acknowledged by law. Designers should demonstrate consciousness of the probability of injury caused by human error and therefore incorporate an alternative design that prevents such likelihood of negligence. Designers should factor into their design the possibility that the end-user is less attentive to following procedures and more susceptible to errors, hence design for human error. An alternative design as long as it is feasible should be allowed for instead of relying on the absence of human error.

In the case of *Ford Motor Co. vs Trejo* (2017), the Supreme Court of Nevada stated that a product is defectively designed if it "fails to perform in the manner reasonably to be expected in light of its nature and intended function and [is] more dangerous than would be contemplated by the ordinary user having the ordinary knowledge available in the community" (p.2). The Court also discussed the liability to determine whether a product is unreasonably dangerous, and stated that a product "is defective in design when the foreseeable risks of harm posed by the product could have been reduced or avoided by the adoption of a reasonable alternative design ... and the omission of the alternative design renders the product not reasonably safe." (p.6), therefore an affirmative proof of a reasonable alternative design is required.

This approach motivates design parties to account for any human error that may have a pacific effect on the final product to achieve a situation where the dangers of human error are significantly reduced. Accordingly, enhance collaboration in exchanging ideas to prevent the contribution of human errors.

- Competency

Competency has a direct influence on design outcome, and absence of competency may lead to serious shortfalls and associated negligence consequences. Successful design can only be achieved if the providers deemed to be competent to provide the best possible standard of care. Organisations need processes to assess, validate, track and maintain or improve competency of their staff.

In the case of *Puckrein vs ATI Transport, Inc*. (2006), the Supreme Court of New Jersey referred to the basic negligence principles, which states:

"An employer is subject to liability for physical harm to third persons caused by his failure to exercise reasonable care to employ a competent and careful contractor (a) to do work which will involve a risk of physical harm unless it is skillfully and carefully done, or (b) to perform any duty which the employer owes to third persons". (p.3)

The Court further explained the liability to employ a competent contractor and stated:

"The employer of a negligently selected contractor is subject to liability under the rule stated in this Section for physical harm caused by his failure to exercise reasonable care to select a competent and careful contractor, but only for such physical harm as is so caused. In order that the employer may be subject to liability, it is, therefore, necessary that harm shall result from some quality in the contractor which made it negligent for the employer to entrust the work to him". (p.3)

Organisations acknowledge the fact that possession of valuable, rare and inimitable resources result in sustained superior performance. Competent professionals have an understanding of their limitations, responsibilities, therefore keen to collaborate to integrate new knowledge and skills into their practice (Jung et al., 2016).

- Intellectual Property

Intellectual property is a form of personal property that is protected by law in an international context. The owner may be granted a remedy to protect its property even no actual damages has been occurred. Although copyright system precludes unauthorised reproduction of the particular expressions of ideas and information, it is imperative that owners have access to legal mechanisms that permit them to protect their trade secrets such as contractual commitments of confidentiality from those given access to secret information. Express commitments that information will not be utilised for a purpose other than that for which it has been communicated are imperative.

Courts, however, might consider an express promise not to use or disclose information against the common law doctrine of restraint of trade, which proscribes undue interference with freedom of trade. In the case of *Maggbury Pty Ltd vs Hafele Australia Pty Ltd,* (2001), the defendant signed a non-disclosure agreement before discussions being held as to the possible exploitation of the plaintiff's idea for a new design of foldaway ironing board. The defendants breached the agreement by using the information to put their rival product on the market. The plaintiff did not attempt to establish the reasonableness of the restraint and Court held that the obligation of non-use was subject to the restraint of trade doctrine, hence unenforceable.

Courts require clear justification for the imposition of restrictions on the use of non-confidential information. Thus it has been held that an obligation of secrecy may be enforced despite the presence of an express obligation which offers only limited protection (see cases *British Industrial plastics Ltd vs Ferguson*, 1939; *Thomas Marshall (Exporters) Ltd vs Guinle,* 1979; and *Cadbury Schweppes Inc vs FBI Foods Ltd*, 1999) or which conversely is unenforceable as being in unreasonable restraint of trade (see cases *Wessex Dairies Ltd vs Smith*, 1995; and *Triple Safety Glass Co Ltd v Scorah,* 1938).

The other general principle of copyright law is that copyright does not extend to ideas, but only to the expression of those ideas. In the case of *Mono Pumps (New Zealand) Ltd vs Karinya Industries Ltd* (1984), the plaintiffs claimed that they had copyright in drawings of pump components, which had been infringed by the defendants. It was held that anyone was free to use the ideas because of the fundamental aspect of copyright law. The idea can be taken but the drawings embodying it cannot be copied.

The definition of "abstract idea" is not articulated in courts. In the case of *Versata Dev. Grp., Inc. vs. SAP Am., Inc., 793 F.3d 1306, 133,* (2015) the court stated:

"Abstract ideas is a problem inherent in the search for a definition of an 'abstract idea' that is not itself abstract." (p.47)

The court in the case *Bilski vs. Kappos, 561 U.S. 593, 611-12, 130 S. Ct. 3218, 177 L. Ed. 2d 792*, 2010 defined abstract idea as:

“Exchanging financial obligations between two parties using a third-party intermediary to mitigate settlement risk."

Abstract ideas were also applied to the concept of risk hedging; an algorithm for converting binary-coded decimal numerals to pure binary concerning; concept of offer-based price optimisation (see cases *Benson, 409 U.S. at 71-72; OIP Techs., Inc. vs. Amazon.com, Inc., 788 F.3d 1359, 1362-63, 2015*).

In addition to the above, processes that are performed by human without the aid of computer such as collecting data using pen and paper or organising human activity are found to be abstract ideas (see cases *Content Extraction & Transmission LLC vs. Wells Fargo Bank, Nat'l Ass'n, 776 F.3d 1343, 1347, 2014; Planet Bingo, LLC vs VKGS LLC, 576 F. App'x 1005, 1007, 2014; Intellectual Ventures I LLC vs. Capital One Bank (USA), 792 F.3d 1363, 1367, 2015*)

Courts consider the collaboration between organisations and the concept of controlled exchange of information as an abstract providing the need for a specialised software does not exist (see case *Open Text S.A. vs. Box, Inc., " 78 F. Supp. 3d 1043, 1044,* 2015), therefore exchanging information via computerised version of interaction between organisations involved in one project working under collaborative environment is not an abstract idea. In concurring option, the court in the case *Monsanto Co. vs. Kamp, 269 F. Supp. 818, 824, 154 USPQ 259, 262,* (1967) held that:

“To constitute a joint invention, it is necessary that each of the inventors work on the same subject matter and make some contribution to the inventive thought and to the final result. Each needs to perform but a part of the task if an invention emerges from all of the steps taken together. It is not necessary that the entire inventive concept should occur to each of the joint inventors, or that the two should physically work on the project together. One may take a step at one time, the other an approach at different times. One may do more of the experimental work while the other makes suggestions from time to time. The fact that each of the inventors plays a different role and that the contribution of one may not be as great as that of another does not detract from the fact that the invention is joint if each makes some original contribution, though partial, to the final solution of the problem.” (p.825)

In BIM-enabled project, participants share their design information which is beyond the ideas, therefore accommodated by copyright protection. Design models are presented and uploaded into the collaborative platform by team members separately based on coding and versioning which protects information against infringement. The intellectual property is protected by law, where breach of confidence entitles the injured party to damages and/or injunction.

- Liability for Misrepresentation

During contractual negotiation, parties are obligated not to make any false statement of fact or law to induce the other party to enter into the contract. The court in the case of *Kleimwort Benson Lts vs Malaysia Mining Corp Berhad* (1989) illustrated that a statement simply asserts the truth of a given state of facts. The claimant agreed to make available to the defendant a €10 million credit facility against letter of comfort from the defendant states that "it is our policy to ensure that the business is at all times in a position to meet its liabilities to you under the agreement". The defendant ceased to trade aftermarket collapse and refused to honour their undertaking to the claimant. The Court of Appeal held that the letter of comfort didn't amount to a contractual promise but merely a representation of fact as to the defendant's policy. However had the defendant's policy, at the time at which they made the statement, not been to ensure that the business at all times be in a position to meet its liabilities, then their statement would have amounted to an actionable misrepresentation. Provision of false information or negligent supply of information for the guidance of others amounts to liability for misrepresentation (see cases *Blue Bell vs Peat, Marwick, Mitchell & Co., 715 S.W.2d 408, 411,* 1986; *Great American Mortgage Investors vs Louisville Title Insurance Co., 597 S.W.2d 425, 429,* 1980*; Shatterproof Glass Corp. vs James, 466 S.W.2d 873, 878,* 1971). In the New York case *Glanzer vs. Shepard, 233 NY 236, 135 NE 275, 23 ALR 1425,* (1922), the Ultramares Court held a public weigher of beans liable for an erroneous weight statement although the buyer requested the weighing. It was emphasised that the buyer would rely on the weight statement.

Fraudulent misrepresentation may set the contract aside notwithstanding good motives (see case *Polhill vs Walter,* 1832) and negligent misrepresentation is actionable in common law and tort (see case *Nocton vs Lord Ashburton,* 1914) regardless the pre-existence of contractual or fiduciary relationship between parties (see case *Hedley Byrne vs Heller*, 1964).

The proposed conceptual framework is underpinned by the courts' approach where parties become liable for any misleading information and thus enhance the level of their accuracy and clarity when sharing information which in turn impact the collaboration positively.

Table 6. 2 Case law in collaboration context

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
People	Socio-Organisational & People Issues	Trust and reciprocity	• Wellington City Council vs. Body Corporate, 2002 • Strzelecki Holdings Pty Ltd vs. Cable Sands Pty Ltd, 2010 • Computershare Ltd v Perpetual Registrars Ltd, 2000 • United Group Rail Services Ltd vs. Rail Corporation (NSW) 2009 • Nala Engineering Ltd vs. Roselec Ltd, 1999 • Secured Income Real Estate (Aust) Ltd vs. St Martins Investments Pty Ltd, 1974 • Peters (WA) Ltd vs. Petersville Ltd, 2001 • Burger King Corp vs. Hungry Jack's Pty Ltd, (2001) • Virk Pty Ltd (in liq) v YUM! Restaurants Australia Pty Ltd (2017) • New South Wales vs. Banabelle Electrical Pty Ltd (2002) • Centennial Coal Co Ltd v Xstrata Coal Pty Ltd (2009) • Carosella v Ginos & Gilbert Pty Ltd [1981] • Moresk Cleaners Ltd v Hicks [1966]	• Good faith should be applicable in all contracts • Good faith and reasonableness are connected to each other, hence should be considered in combined • The implied duty to cooperate between contracting parties, is a prerequisite to enable the fundamental benefits of the contract. • Contracting parties are under fundamental obligation to cooperate to achieve the contractual goals • Contracting parties are obligated to apply trust and good faith in resolving their disputes	• The proposed collaborative structure assumes mutual respect between participants. Insert contractual clause urging participants to build climate of trust to enhance business engagement • Implement regular face to face communication between participants to share information throughout the process. • Implement joint decision making system to enhance level of trust between participants • Implement social communication platform between participants to exchange social events and kickoff trust • Firewalls and encryption need to be rational when it comes to exchanging information of normal level of security

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
People	Socio-Organisational & People Issues	Shared responsibility	• National Museums and Galleries on Merseyside Board of Trustees v AEW Architects and Designers Ltd (2013) • Esso Petroleum Company Ltd v Scottish Ministers and Others (2016)	• Sharing liability for risks increases the likelihood of exceeding expectations • There is no provision in Australian law that mandate parties to share risks and liability • When circumstances accelerate in the wrong direction, an enforceable negotiation is what Australian law provides when third party of an expert is involved to negotiate and decide on the dispute • Liability to provide requisite design criteria for all works rest with the Architect • Client holds no liability to any damage results from works he contracts which can be performed at no risk to adjacent property however share responsibility with the contractor for damage to adjacent property when works is necessary attended with risks. Merely binding the contractor to take effectual precautions is not enough to free himself from liability for damage	• The essence of collaboration is to share liability for achieving common objectives. • The proposed collaborative structure stipulates participants' obligations and entitlements, which in turn promotes integration rather than single end of responsibility. • Owner, designer and contractor are the main parts of the proposed structure. Obligation to share liability for work that could risk adjacent property motivates collaborative activities.
		Incentives	Simister, 2001 Bower et al. 2002 Turner, 2004 W. Hughes et al. 2007	• Collaboration is driven by benefits that shared between contracting parties • Financial rewards induce behavior change towards better productivity and efficiency • Re-contract award promise motivates better work deliverables	• Set general rewards to achieve common objectives • Set special rewards for participants with expertise and knowledge to share information between team members • Set regular recognition of outstanding work with financial rewards to encourage collaborative work behavior • Identify poor performanc and set motivation scheme

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
People	Socio-Organisational & People Issues	Education and awareness	Sanches & Mahoney, 1996 O'dell & Grayson, 1998 Maier & Hadrich, 2011 Yew Wong, 2005	• Education contribute into culture change, hence impact communication plans and willingness to interact collaboratively between people • Education contribute towards changing organisation's culture and its main aspects of attitudes and shared values, hence teams' pervasiveness and strength • Facilitate the creation of decentralised oganisational structure that supports productive power and effectiveness and influence the level of autonomy to participate in collaborative decision making process. • Impact coordination between employees and conflict resolution • Decision making is not contingent on a hierarchy of authority but made by skilled employees who understand the issues	• Stipulate the responsibilities and limitations of each team to enable collaborative awareness • Understand the expertise and skills of team members and corresponding preferences to reduce coordination demands • Share regular status report and resources availability between teams to avoid conflicts and hence function effectively • Share knowledge between members to enhance cohesion and task performance • Apply self-interested motivations as incentives to achieve objectives and avoid sanctions
Process	Information Sharing	Duty to alert	• Comptroller of Virginia ex rel. Virginia Military Institute v. King (1977) • Surf Realty Corp. v. Standing (1953) • Willner v. Woodward (1959) • Beshada v. Johns-Manville Prods. Corp. [1982]	• Consequences resulted from obvious errors in design need to be disclosed to owner • Contractor is not liable for the Architect's design however contractor is liable to notify design errors if they are well known to the contractor's trade • Architect is reasonably expected to disclose defects in construction regardless such defects are resulted from design errors or deviation by the contractor from design plans.	• Duty to alert motivates all participants to highlight any incident that raises reason for safety concern • Establish regular workshops between participants to discuss design outcomes and references to standards and guidelines • Establish workshops between design and construction teams to discuss construction progress and compliance with the approved design elements. This means extending the involvement of the design team to allow for spot site visits during construction phase and review of BIM model as and when updated

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
Process Information Sharing	Process Information Sharing	Information integrity	• Cobell v. Babbitt, 91 F. Supp. (1999) • Resdev, LLC v. Lot Builders Ass'n (2005) • Rippey v. Denver United States Nat'l Bank (1967) • SEC v. Sargent (2000) • United States Gypsum Co. v. Lafarge N. Am. (2009) • United States v. Mitchell (1983) • Worldspan L.P. v. Orbitz, LLC (2006) • Cobell v. Norton (2001) • NetApp, Inc. v. Nimble Storage (2015) • Horiike v. Coldwell Banker Residential Brokerage Co. [2016]	• Information that flows between contracting parties need to be verified and monitored. • The integration between parties' computer system is essential to ensure information's integrity • Information need to be safe guarded from unauthorised destruction or alteration by unauthorised parties • All contracting parties are under duty to protect information from unauthorised access • Impairment to information/data integrity is a prerequisite to claim for damages • Damage to information/data such as deletion, corruption. Destruction of whether hard copies or electronic files in computer system constitute a claim for compensation • Parties in contract are liable for digital misrepresentation which involves copying information	• The proposed collaborative structure assumes information sharing culture under environment of trust. • Establish information processes policy to stipulate information flow between participants • Coding and versioning is assumed to protect the integrity of design related information • Rules to re-use information to evolve the design model are set within the quality control stage • Right information is transmitted to right people at right time • Security and efficiency perspectives are maintained. This means setting out access level with protected passwords

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
Process	Information Sharing	Information ownership	• Axelrod & Cherveny Architects, P.C. v. Winmar Homes (2007) • Cmty. for Creative Non-Violence v. Reid (1989) • Cornerstone Home Builders, Inc. v. McAllister (2004) • Donald Frederick Evans & Assocs. v. Cont'l Homes (1986) • Everex Sys. v. Cadtrak Corp (1996) • Harris v. Emus Records Corp. (1984) • Hogan Sys. v. Cybresource Int'l. (1998) • HRH Architects, Inc. v. Lansing (2009) • Lulirama Ltd., Inc. v. Axcess Broadcast Servs. (1997) • M.G.B. Homes, Inc. v. Ameron Homes (1990) • Nilson v. McGlaughon (2004) • Bonner v. Dawson (2003) • SQL Solutions v. Oracle Corp. (1991) • Fred Riley Home Bldg. Corp. v. Cosgrove (1994) • Womack+Hampton Architects, L.L.C. v. Metric Holdings Ltd. P'ship (2004)	• The author/s of work translates an idea into an actual work that is entitled to copyright • Courts grant copyright ownership to the original author of work • Courts recongise the person who asks for a work to be done and pays for it as the author of that work and grant him with copyright • An architect who develops design based on ideas provided by another party owns the copyright. The contribution of the party who provided the idea/concept does not constitute basis for co-authorship claim • Architect's design and drawings are protected by copyright unless there is an overwhelming degree of similarity with other work • The eye of an ordinary person is the judgment for similarity between two works. In the context of an architectural design, substantial similarity between two works is considered design infringement, even if other dissimilarities exist • Independent contractors who use software owns by the main contractor to carry out work that the main contractor will benefit from do not require transfer of software license. • Impermissible transfer if not considered	• The proposed collaborative structure presents the work of each participant separately • Participants use each other design models to update their work • The law helps to protect each participant's design from infringement which motivate parties to collaborate

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
Process	Information Sharing	Professional negligence	• City of York v. Turner-Murphy Co. (1994) • Conforti & Eisele, Inc. v. John C. Morris Associates (1980) • Congregation of the Passion v. Touche Ross & Co. (1994) • Doe v. American Red Cross Blood Services (1989) • Hill v. Polar Pantries (1951) • Hoeffner v. Citadel (1993) • Kemin Indus. v. KPMG Peat Marwick LLP (1998) • Mid-Western Elec. v. DeWild Grant Reckert & Assocs. Co. (1993) • Owen v. Dodd (1977) • Robert E. Lee & Co. v. Commission of Public Works (1966) • Schipper v. Levitt & Sons, Inc. (1965) • Snavely v. AMISUB of South Carolina, Inc. (2008) • Sommer v. Federal Signal Corp. (1992) • Sunland Constr. Co. v. City of Myrtle Beach (2008) • Tommy L. Griffin Plumbing & Heating Co. v. Jordan, Jones & Goulding, Inc. (1995)	•Legal duty must exist to claim for negligence damage •Courts require an expert testimony to establish the standard of care and the alleged professional deviation unless the issue of common knowledge and no special learning is required •Designers are liable for defective design and contractors are liable for defective material and workmanship •Designers hold an implied liability that their design is fit for purpose •Owners and designers hold liability if they furnish the contractor with defective design and specifications •Failure to achieve the standard of care warrant a claim for negligence •Professional negligence might result in tort action if the tortfeasor and the injured party are in a special relationship •Architects and contractors are liable for professional negligence even after the work has been completed and handed over to the owner •Failure to comply with design guidelines result in negligence claim •Architect who delegates his design duties to a specialist subcontractor remain liable for all actions of commission and omission of that subcontractor unless Client's approval to accept such delegation of responsibilities exists	• Obligate participants into contract terms that stipulate the required legal duty • Separation between participants' models and tracking of changes scheme help to assign liability for defective design, hence risk resulted from negligence cannot be transferred. • Designers become keen to collaborate and produce fit for purpose design model

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
Process	Information Sharing	Professional negligence	• Totten v. Gruzen (1968) • Waldor Pump & Equipment Co. v. Orr-Schelen-Mayeron & Associates, Inc. (1986) • Young v. Tide Craft, Inc. (1978) • Koontz v. Thomas (1999) • Bd. of Trs., Cmty. Coll. of Baltimore County v. Patient First Corp. (2014) • Harris Constr. Co. v. GGP-Bridgeland, L.P. (2010) • Carosella v Ginos & Gilbert Pty Ltd (1981) • Moresk Cleaners Ltd v Hicks (1966) • E.g., Cowles vs City of Minneapolis [1915] • Peterson vs Rawson [1857] • Sherman vs Miller Construction Co. [1927] • Barraque vs Neff [1942] • Bayshore Development Company vs Bonfoey [1918] • Day v. National-U. S. Radiator Corp. [1959] • Clemens v. Benzinger [1925]		

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
	Digital Engineering	Admissibility in evidence	• Lorraine v. Markel Am. Ins. Co. (2007) • Anton Piller KG v Manufacturing Processes Ltd (1975) • Greene v Associated Newspapers Ltd (2004) • Simsek v MacPhee (1982) • Subramaniam v Public Prosecutor on Appeal from the Supreme Court of the Federation of Malaya (1956) • L'Estrange vs Graucob [1934]	• Electronic documents stored in computer system constitute no authentication issue • The complexity and novalty of the electronic system determine the requirement to authenticate the electronic documents • Errors can occur during the development of computer data, which in turn adversely impact the accuracy of the outcome. • Inaccurate data entry or defective software results in corrupted data • The requirement to authenticate computer-based data is relied upon the quality of data inputting, operating system complexity; and possibility to test the computer processing and verify the results • Electronic documents can also be authenticated by witness with knowledge	• Participants realise the paradigm shift in information management where electronic records can now be used as evidence in judicial or administrative proceedings • Participants take responsibility for maintaining the evidential value and provenance of every electronic document. • Participants become keen to ensure the accuracy of their documents. This in turn increases the relevancy and reliability of their documents while transferring to other users. • Collaboration process become more efficient as every participant delivers their data on time with best level of accuracy which accordingly diminishes rework time • With the implementation of security application to protect the data such as assigning user ID and password, participants become less concerned about the safety of their electronic documents and hence reduces their hesitation to exchange data with others
		Data authentication	• United States v. Vayner (2014) • Sublet v. State (2014) • United States v. Al-Moayad (2008) • United States v. Maldonado-Rivera (1990) • United States v. Pluta (1999) • United States v. Rommy (2007) • United States v. Sliker (1984)	• Authenticated evidence is a prerequisite to courts admissibility • Testimony from a person with knowledge to confirm the authentication of a document is acceptable • Document's appearance, content. internal pattern and any other distinctive characteristics can be used to authenticate the document • Evidence authentication lead to court admissibility however reliability of that evidence is contingent on its importance and relevance and its interpretations	• Incorporate delivery report to record the information that parties exchange between them

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
	Digital Engineering	Unauthorized use of data by others	• Bliss v South East Thames RHA (1985) • Dalgety Wine Estates Pty Ltd v Rizzon (1979) • Heywood v Wellers (1975) • HUB Group, Inc. v. Clancy (2006) • Jarvis v Swans Tours Ltd (1972) • Seager v Copydex Ltd (1967) • Cf Smith Kline & French Laboratories (Australia) Ltd v. Secretary, Department of Community Services and Fraser v Evans (1969) • Ansell Rubber Co Pty Ltd v Allied Rubber Industries Pty Ltd (1967) • Johns v Australian Securities Commisison (1993) • O'Brien v Komesaroff [1982] • Johnson vs Heat & Air Systems Ltd [1941]	• Accessing a protected computer intentionally and without authorization constitute claim for damages • A party knowingly accessing data without proper authorization is liable for all damages • Disclosure of information or using it beyond the agreed on purpose is considered as unauthorised use and hence breach in confidence. This is regardless if such action was intended or unintended by way of negligence • Third part who encourage or participate in breaching information confidentiality will be liable for contractual remedies	• It is essential for participants to identify the confidential information which needs to be accurate and not merely global or common knowledge. • With the possibility to identify the scope of protection and set the purpose for information disclosure, participants become more comfortable in exchanging information within collaborative framework • Enforce duty confidence where participant bear liability to allow others to learn of information or subconsciously plagiarise secret idea negligently by error or intentionally.

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
Technology	Technology, Info. Accessibility (Design and Administration)	Human error and manipulation	• Ficep Corp. v. Voortman (2017) • Gasque v. Heublein, Inc (1984) • Kennedy v. Custom Ice Equip. (1978) • Claytor v. Gen. Motors Corp. (1982) • Sunvillas Homeowners Ass'n v. Square D Co (1990) • Bragg v. Hi-Ranger (1995) • Entergy Gulf States, Inc. v. Louisiana PSC, (1999) • Ford Motor Co. v. Trejo (2017) • Keeter v. Alpine Towers Int'l (2012)	• The process of creating design model in an electronic format should be performed without the possibility of human error • Management is liable to correct procedural adherence problems to prevent human error • Inadequate and unreasonable management practices furnish basis for a finding of imprudence. Human error should be avoided. • Design model of multi-component object should include specifications of the separate components • Human error should be considered when design a product, and to avoid the foreseeable risks, a reasonable alternative design should be adopted if so is feasible • Human error is an intervening act that breaks the chain of causation between a defendant's negligence and an injury which makes the defendant liable for that injury.	• Errors in communicating information within the team, deviation from design/construction rules and regulation due ignorance of such regulations and failure to report defects or lapses due to lack of error management and organisational learning scheme impede proper decision making and hence impact the collaborative work between cross-functional teams.
		Competency	• Mavrikidis v. Petullo (1998) • Huber v. Seaton (1989) • King v. Lens Creek Ltd. (1996) • Puckrein v. ATI Transport, Inc. (2006) • Asphalt & Concrete Servs. v. Perry (2013)	• Lack of insurance and/or financial resources to respond to damages are not necessarily proof of contractor's unfitness to carry out the works. • Unless contractually stated, poor financial condition, insurance and registration with various association and affiliation are not competence related issues.	• Participants hold various levels of knowledge and skills which they will bring into collaboration • In absence of motivation, collaboration may not mirror the actual level of participants' competency • Different levels of competency may impact communication level and behavior unless an agreed on procedural framework exists.

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
Technology	Technology, Info. Accessibility (Design and Administration)	Intellectual property	• John G. Danielson, Inc. v. Winchester-Conant Props. (2002) • T-Peg, Inc. v. Vt. Timber Works (2006) • Nat'l Med. Care, Inc. v. Espiritu (2003) • Music Sales Ltd. v. Charles Dumont & Son, Inc. (2009) • Carell v. Shubert Org., Inc. (2000) • Morgan v. Hawthorne Homes, Inc. (2009) • FMC Corp. v. Control Solutions, Inc. (2005) • Rottlund Co. v. Pinnacle Corp. (2004) • Aftermarket Tech. Corp. v. Whatever It Takes Transmissions (2003) • Harvester, Inc. v. Rule Joy Trammell + Rubio, LLC (2010) • TMTV, Corp. v. Mass Prods., Inc. (2004) • Fin. Control Assocs. v. Equity Builders, Inc. (1992) • City of New York v. GeoData Plus, LLC (2007) • Pem-America, Inc. v. Sunham Home Fashions, LLC (2003) • Penguin Books U.S.A., Inc. v. New Christian Church of Full Endeavor, Ltd. (2000) • Teter v. Glass Onion, Inc. (2010); • Atkins v. Fischer (2001) • Corbello v. Devito (2015) • video Pipeline, Inc. v. Buena Vista Home Entm't, Inc. (2003) • Lowe v. Loud Records (2003) • Venegas-Hernandez v. Peer (2004) • I.A.E., Inc. v. Shaver (1996) • E I Du Pont de Nemours & Co Inc v Christopher (1970) • Maggbury Pty Ltd vs Hafele Australia Pty Ltd, [2001] • British Industrial plastics Ltd vs Ferguson [1939] • Thomas Marshall (Exporters) Ltd vs Guinle [1979] • Cadbury Schweppes Inc vs FBI Foods Ltd [1999] • Wessex Dairies Ltd vs Smith [1995] • Triple Safety Glass Co Ltd v Scorah [1938] • Mono Pumps (New Zealand) Ltd vs Karinya Industries Ltd [1984]+D19	• Technical details, diagrams and models form part of the design drawings for any project. • Low requisite level of creativity suffice copyright protection. • Independently created work yet original with minimal degree of creativity entails copyright protection • Design work to be registered for copyright protection need to be either original where an existing design creatively evolved or new design has not been applied before. • Nonexclusive license to use a design exists when the licensee request for a design, licensor delivers the design and licensor intends that the licensee copy and distribute the created deign	• Knowledge in wealth and information is the most valuable commodity. Participants in BIM project need to be encouraged and incentivized to share information • Commercial gain from ideas is recognized by intellectual property rights. Therefore participants in BIM project need their effort and knowledge be legally protected to facilitate the investment in developing and sharing information via collaboration framework. • Due to the ongoing array of sophisticated information gathering techniques, legal mechanism to safeguard information from unauthorised reproduction of ideas and information is required. Contractual commitments of confidentiality is needed to protect the trade secrets.

Category	Group	Variable	Precedence Case-law Reference	Key Finding	Implication on Collaboration Framework
Technology	Technology, Info. Accessibility (Design and Administration)	Liability for misrepresentation	• Dura Pharms., Inc. v. Broudo (2005) • Soules v. General Motors Corp. (1980) • McMeen v. Whipple (1961) • Buechin v. Ogden Chrysler-Plymouth, Inc. (1987) • Hicks v. Deemer (1900) • Munjal v. Baird & Warner, Inc.(1985) • Kinsey v. Scott (1984) • Dinsdale Constr., LLC v. Lumber Specialties, Ltd. (2015) • Pitts v. Farm Bureau Life Ins. Co. (2012) • Sain v. Cedar Rapids Cmty. Sch. Dist. (2001) • Van Sickle Constr. Co. v. Wachovia Commercial Mortg., Inc. (2010) • Employers Mut. Cas. Co. v. Collins & Aikman Floor Coverings, Inc. (2004) • Fox Assocs., Inc. v. Robert Half Int'l, Inc. (2002) • Wachs Tech. Servs., Ltd. v Praxair Distr., Inc. (2012) • Larson v. United Fed. Sav. & Loan Ass'n (1981) • Jane Doe 3 ex rel v. White (2011) • Singer v. Beach Trading Co. (2005) • City of Chicago v. Michigan Beach Hous. Coop. (1998) • K & J Group, Inc. v. Deli Time, LLC (2012) • Kleimwort Benson Lts vs Malaysia Mining Corp Berhad [1989] • Polhill vs Walter [1832]	• Fraudulently made misrepresentation leads to liability for pecuniary loss. • Tort law identifies the elements of fraudulent misrepresentation as a- false statement of material fact; b- known or believed to be false by the party making it; c- intent to induce the other party to act; e- action by the other party in [justifiable] reliance on the truth of the statement; and f- damage to the other party resulting from such reliance • The difference between the value at which a product was sold and the value that the same product would have had if the representation had been correct is the calculated misrepresentation damage • The manufacturer and supplier of a products liable to render accurate information about the product installation and adequacy for the intended work. • Personal injury and property damage resulted from misrepresentation are treated like any other negligence claim • Parties in an advisory capacity who supply information and are manifestly aware as how such information is intended to be used are liable for any misrepresentation • Manufacturers are not in the business of supplying information • The theory of misrepresentation is applicable to the bankers render the buyers with evaluation report of a property if failed to disclose any critical disclose defects in the property which they are aware of • The theory of misrepresentation is applicable to the employer if voluntarily opted to supply employment reference.	• Misleading statements and false representation by any participant as to standards, quality, level of services, grade, place of origin, value and the like hold misrepresentation liability which in turn negatively impact collaborative processes. Legal contract and policy are needed to govern roles and responsibilities

6.3 Chapter Summary

This chapter presented precedents from case-law to legitimatise the core dimensions of collaboration and associated variables that were identified in the research. The purpose of investigating previous court judgments was to test the feasibility and practicality of the proposed governance-based framework in conjunction with existing contract forms.

With this primary purpose, the factual and procedural background, discussion and conclusion of various cases were described and referenced to each of the identified variables that impact collaboration. The court judgments confirmed the legal extent of all proposed variables and established legal viewpoints that can be utilised to amend the existing contractual arrangements. Therefore facilitates the creation of a contractual structure that engages all parties actively, and hence enable substantial improvement in collaboration between project stakeholders.

The outcome of this chapter is invaluable as it forms the foundation of effective factors for adopting BIM within a collaborative environment. In addition to the technical aspects, the conceptual collaboration framework proposed in this research also considers the socio-organisational and process aspects. In the following chapter, the developed framework will be validated through 15 in-depth semi-structured interviews with industry practitioners

CHAPTER 7 VALIDATION

7.1 Chapter Introduction

The conceptual governance framework which was developed from the exploratory interviews provided an understanding of the issues influence the nature of collaboration in BIM-enabled projects. The feasibility and practicality of incorporating the identified collaboration principles into existing contract forms have been examined in the previous chapter using precedents from case-law.

In this chapter, a qualitative study is presented to validate and modify the proposed framework to suit the actual needs. Fifteen in-depth semi-structured interviews with industry experts were conducted to obtain their views and opinions.

After conducting the interviews, robust understanding was evident that sharing knowledge and information, trust and acting in good faith, striving for common objectives are needed for collaboration which all engendered by organisations' culture and leadership structure. The proposed conceptual framework was presented, and participants exhibited an explicit agreement that the proposed collaboration dimensions and associated variables need to be enacted and incorporated into the existing legal structure. The outcome of the interviews is reported in this chapter.

7.2 Data Collection

Semi-structured face-to-face interviews with senior managers/directors of major organisations were undertaken to obtain expert opinions. Fifteen industry experts from various organisations were selected (Table 7.1). These being project sponsor, service consultant, project manager, quantity surveyor, architect, contractors, client representative and engineers who had experience of working in a BIM environment and delivering a federated model for asset management.

The participants and their corresponding organisations who have taken part in this research, in addition to other attributes such as their years of experience, area of expertise are demonstrated in the below themes extracted from Nvivo12 program.

The interview process was similar to that described in chapter 5. Accordingly a semi-structured interview guide was prepared based on which all interviews were carried out (Appendix B). The interviews were kept open allowing for more general questions to be used enabling the interviewer and the person being interviewed the flexibility to probe for details and/or to discuss more appropriate topics relating to effective collaboration working issues. As such phrases such as ‘what is your opinion’ or “explain to me’ were used which stimulated avenues of interest for further discussion without biased response. All interviews were digitally recorded. However additional notes were taken during the sessions to validate and safeguard the discussed material against digital recorder’s failure. Each interview lasted between 60-90 minutes.

The results of these interviews are discussed in the section below. The data collected from interviews was verified with the participating organisations. Classification of respondents and associated demographic information are presented in Appendix D

Table 7. 1 Sample information of the exploratory study

Interviewee	Number	Serial Code
Contractor	3	C-01 TO C-03
Project Manager	4	PM-01 to PM-04
Service Consultant	1	SC-01
Mechanical Engineer	1	ME-01
Electrical Engineer	1	EE-01
Client Representative	1	CR-01
Structural Engineer	1	SE-01
Quantity Surveyor	1	QS-01
Project Sponsor	1	PS-01
Architect	1	A-01

7.3 Results from Interviews

The aim and objectives of the research and the findings from the first session of interviews were briefly explained to each interviewee. The explanation was followed by an overview of the conceptual governance framework and collaboration main dimensions that were previously developed and identified (Figure 7.1). The aim was to discuss the feasibility of the conceptual framework model to enhance collaboration between all stakeholders and hence motivate the adoption of BIM across the lifecycle of construction project. More specifically, obtaining professional opinions from various industry experts about the proposed variables that are associated with collaboration core dimensions and what implementation environment that is best suited to address information sharing and technology challenges.

All interviewees acknowledged that team members must have a clear understanding of what the deliverables and expectations are prior to get into the design development phase. According to the comments that were raised by the interviewees, the proposed variables that are associated with each core dimension substantially ameliorate the interaction between team members and thus influence collaboration, decision making, communication and information sharing, conflict resolution and overall operation performance. Insight on each of the variables, their importance, and how influence collaborative work are discussed in the sections below

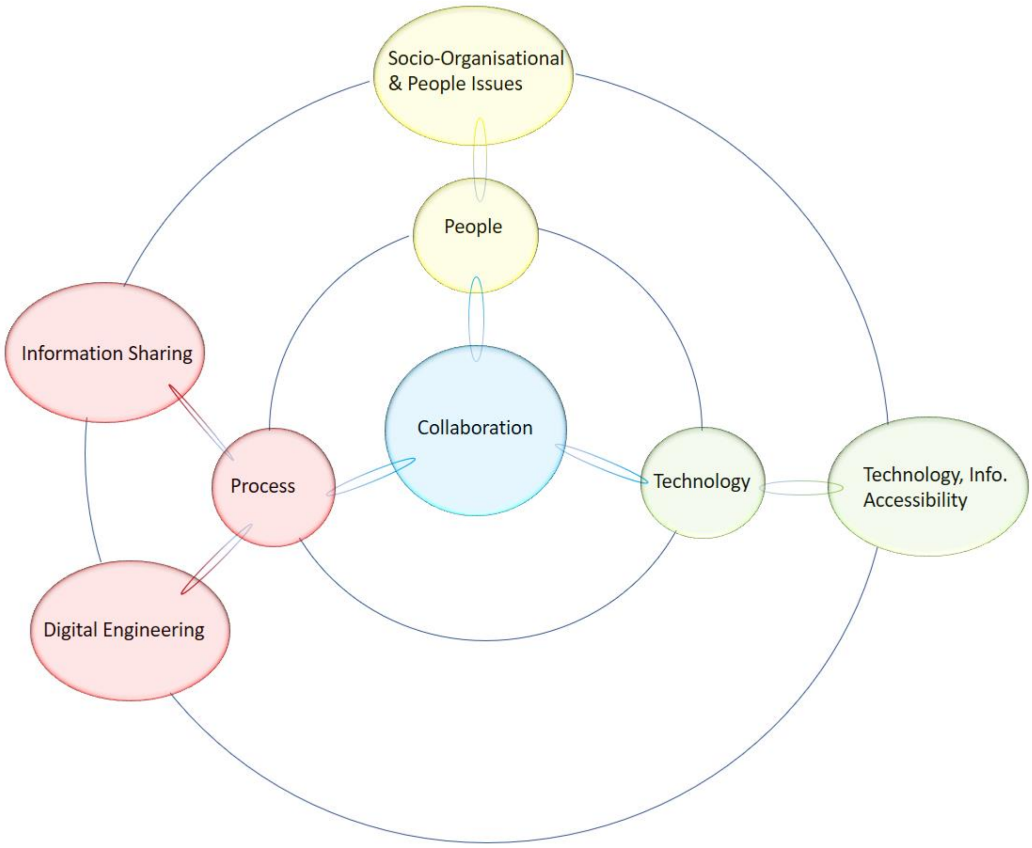


Figure 7. 1 Collaboration core dimensions and associated variables

7.4 Conceptual framework – tenets of collaboration

The three distinct tenets of collaboration which were discussed in chapter 5 are listed below along with associated variables that, the interviewees deemed would enable collaboration to manifest. There was an overwhelming consensus that teams in BIM-enabled project need to access, understand and share the information that BIM brings together. Education and awareness ranked first in priority, supported by process and technology.

7.4.1 People

Organisations provide structure and boundaries relevant to responsibility, functionality and authority to their team members. Such structure set policies and processes outlines, and define the extent of tasks, trust, learning and incentives for participation. The interviewees considered effective teamwork is associated with team structures that match the tasks to be performed, while autonomous teams are associated with improved productivity in the case of high task interdependence.

All firms stated that decentralised organisations in terms of responsibilities are characterised as high-performance workplaces with better flexibility to address changes as opposed to traditional work organisations. Sharing responsibility rather than relying on a hierarchy of authority supports the ultimate personal, team and organisational objectives. Below themes (Figure 7.2) are extracted from Nvivo 12 based on the interviewees' feedback which illustrates the first core dimension and its associated variables:

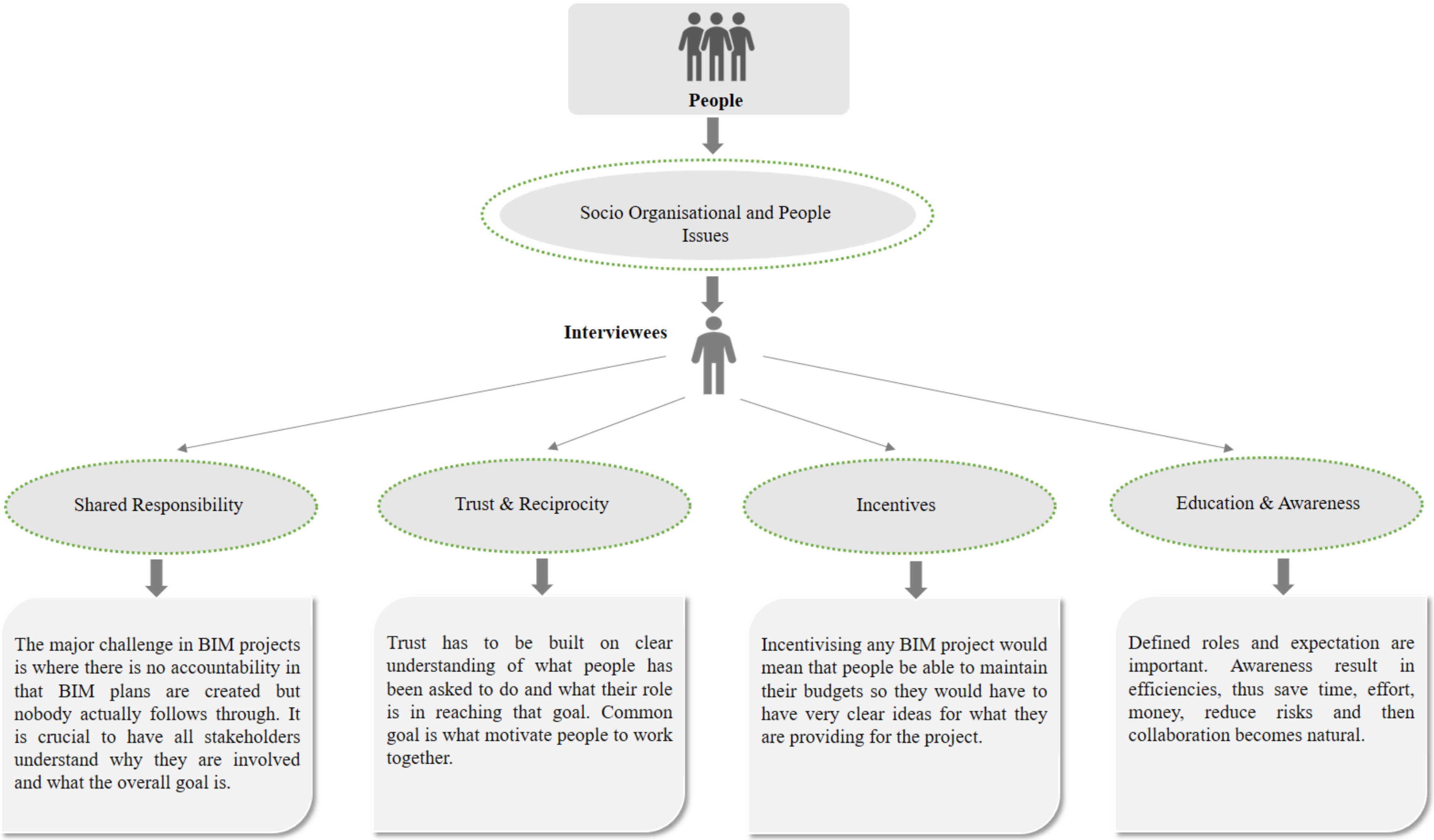


Figure 7. 2 People: main and sub-factors of collaborative Work

- Shared Responsibility

The respondents acknowledged the lack of a clear understanding as what collaboration entails and how to best achieve the common goals. However, they stressed the need for a descriptive model that identifies what influence collaboration. Interviewees stated that sharing responsibilities motivates participants to collaborate as long as team members appreciate the ultimate objectives, their responsibilities and what they are contributing to in a clear set out terms.

An architect from design consultancy firm (A-01) made the following comment:

> "Sharing responsibilities can certainly motivate participants to collaborate as long as few conditions met. People must involve in a project to understand why they are involved and what the overall goal is in really clear set out terms and what is it that they are trying to achieve together and then secondly what their responsibilities are. So if you are going to have multiple parties involved, they must understand what they are contributing to so there is no confusion over how they are involved."

Task characteristics was recognised as the main attribute that affect collaboration. There was an agreement that parties who are BIM-ready should only be involved in a BIM-enabled project; else project will end up going back towards old ideas.

- Trust and Reciprocity

Organisations need to provide management support and resources to their teams to enable them to collaborate with all internal and external stakeholders as required. Although collaboration is a social activity that requires interaction between individuals who contribute to organisational objectives, individual performance remains crucial to the performance of teams.

Interviewees identified trust as central to team performance. Trust of being given the best management support, means of communication and technology, security and confidentiality, and business to business collaboration. All firms stated that trust is a little bit difficult commodity in the modern world; however, it has to be built on clear understanding of what participants have been asked to do and what their role is in reaching that goal. Knowing the ultimate objective is a good foundation for all participants to work together to build trust

A project manager (PM-01) commented on the impact of trust on collaboration and stated:

> "Trust is the most important factor. We need to have some agreed ways to resolve issues if they arise. There is always something will come up no matter how well you plan and the test of how well people work together is how quickly and easily they can resolve that"

- Incentives

Personal interests have been highlighted as a potential driver for collaboration. Teams of conflicting goals lead to adversarial collaboration and tendency to share information as necessary partially. Interviewees stated that team members need to focus on working together to maximise team outcomes, communicate and share knowledge. Joint action can be achieved by implementing motivation schemes and assigning rewards towards team objectives rather than individual aims. A contractor (C-01) stated:

> "There is no doubt that economic benefits drive collaboration."

Incentives in the form of financial gains, work recognition, improving work environment, improving status, reducing workload. All firms agreed that incentives motivate people to collaborate with each other. A quantity surveyor (QS-01) corroborated with the above and stated:

> "It is essential to understand what motivates organisations to activate their participants at the right time. Incentives facilitate the formation and stability of network linkage."

- Education and Awareness

Interviewees agreed that understanding roles and responsibilities is incredibly important to facilitate collective work and enable teams to work together.

A project sponsor (PS-01) commented:

> "Defined roles are incredibly important and expectation about how people interact in that if a problem comes up how to behave and resolve that issue. The culture of being constructive in your approach is essential."

In stressful situation; teams function effectively when collaborative awareness exists. All firms acknowledge that education and awareness reduce the need for coordination without compromising task performance. Homogeneous and stable team membership influence shared knowledge positively, and hence result in greater common ground for better collaboration and productivity.

A structural engineer (SE-01) further clarified and stated:

> "Education and mutual understanding of working practices help to establish trust, improve teams' adaptability, and reduce error and poor decision making."

7.4.2 Process

The overarching mechanism that gives rise to collaboration is deemed to be the coordination process between project parties. Models developed by various engineering discipline consultants evolve through alignment and overlaying process to achieve the ultimate federated model.

Steiner (1972) clarifies that process is collective of actions to achieve an objective and states: "the individual or collective actions of the people who have been assigned a task… process is a series of behaviours, one following another, each determined to some degree by those that have gone before and each, in turn, influencing those that will come later" (p.8)

Interviewees highlighted that collaboration is engendered by the interaction process of communication, information sharing, coordination and decision making that take place between teams throughout the project lifecycle. An engineering services design consultant (SC-01) commented on that and stated:

> "The productivity is contingent on the proper pattern of collective actions."

Teams through design coordination and models' alignment process convert their resources into the single point of truth model. All interviewees stressed that coordination process facilitate consensus on the actions to be undertaken. However, all firms explicitly stated that motivating collaboration and enhancing alignment between teams throughout design development and construction stages would result in running BIM collaboratively.

Below themes (Figure 7.3) are extracted from Nvivo 12 based on the interviewees' feedback which illustrates the process component and its associated variables:

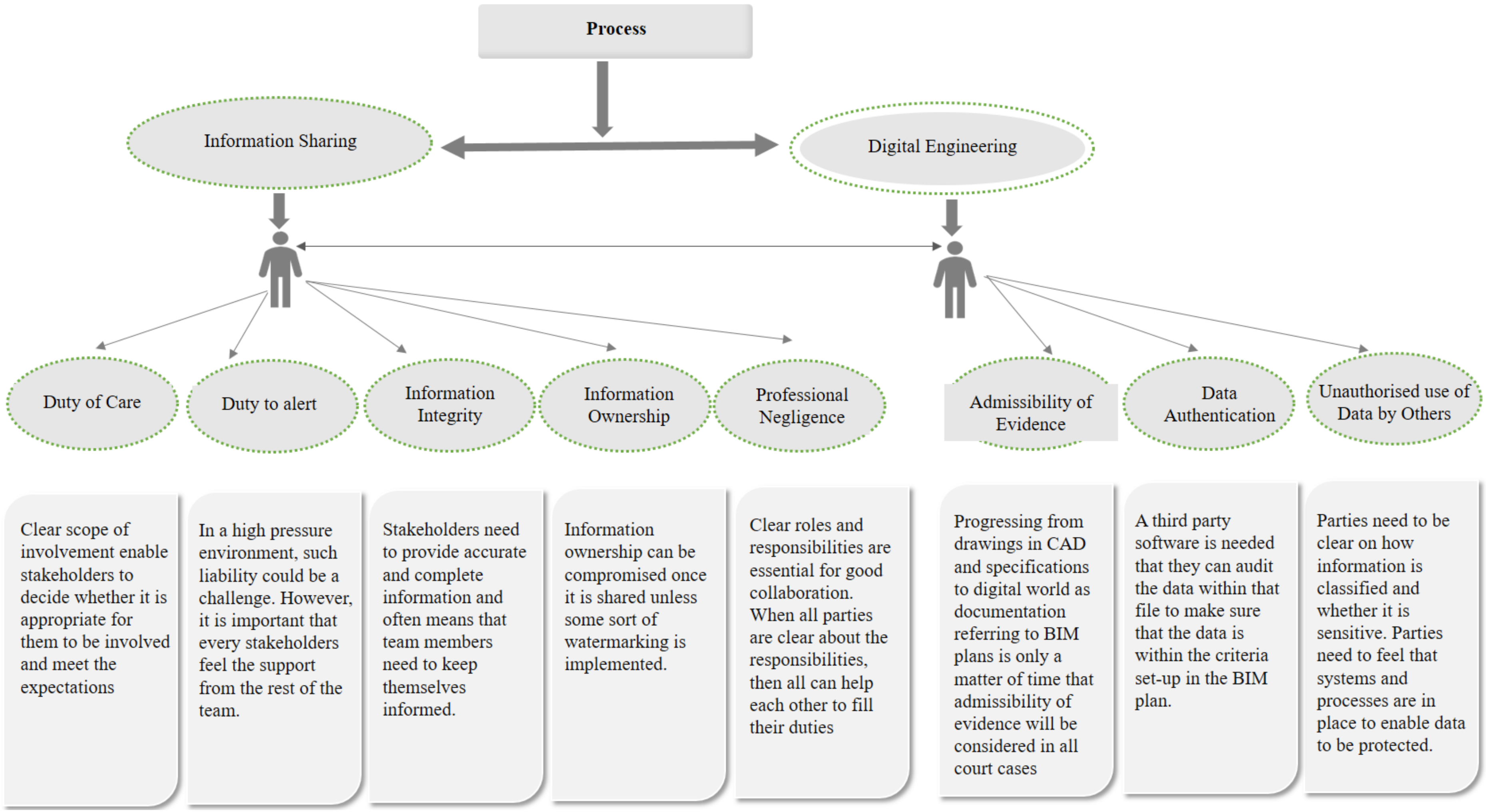


Figure 7. 3 Process: main and sub-factors of collaborative work

- Duty of Care

There was an agreement that duty of care is part of the rules of engagement when expectations need to set up-front and scope of involvement made clear. People can then decide whether it is appropriate for them to be involved. Interviewees believe that duty to exercise ordinary care makes teams working together in one project mindful of negligence. A client representative (CR-01) commented on that and stated:

> "In a collaborative work environment, each party is liable to perform a role or task. Regardless if that role or task involves risk of injury to others or not, imposing duty of good faith liability shall ensure that each party perform their role carefully."

Duty of care encourages teams to ensure sharing reliable and accurate information when needed and work together to avoid wrongful act. Foreseeability and reasonable certainty of injury make project parties cautious to avoid omissions and facilitate collaborative work environment. All firms agreed that foreseeable damage place all project parties under liability to protect each other, which abundantly motivate collaboration.

- Duty to Alert

All firms shared similar view and agreed that duty to warn defect or omission place project parties liable for ensuing damages, and therefore motivate collaboration to ensure that the final product is reasonably fit, safe and suitable for the intended purpose to all potential users. A project manager (PM-02) stated:

> "The obligation about informing defects is essential as it enables parties to make an understanding and enlightened decisions. However, to impose such liability, all parties involved in the project must acknowledge that they will support each other to address the reported omission."

In the design process, parties will be more keen to work together to produce a defect-free design where risk has been reduced to the greatest extent possible to ensure consistency with its continued utility.

- Information Integrity

Interviewees emphasised the importance of knowledge sharing culture in an organisation. Better understanding of work activities is gained when teams manage, store and share information. There was general agreement that conserving and using knowledge as necessary to enhance future performance. Knowledge should be kept up to date too, and to do that organisations need to invest in maintaining collaborative support systems, developing guidelines and policy, and create processes to ensure all team members are aware of the information that need to be shared.

The liability for providing accurate and complete information influence how teams perform and support the collaborative system. This was best summarized by a participant from a construction company (C-02) firm who commented:

> "Information integrity impact team effectiveness and motivate project parties to complete their tasks in a collaborative manner and hence achieve the required objective".

The same comment was corroborated by a project manager (PM-04) who stated:

> "Communicating information between project teams enable an environment of trust, and information integrity enforce such trust and support the collaborative work systems".

- Information Ownership

Interviewees identified design copyright and authorship and were in agreement that protecting original works enhance teams' psychological involvement in their tasks, and motivate them to collaborate and share design information. A participant from architectural design consultancy (A-01) argued that:

> "We shared information in CAD files for many years, people generally have to share their models especially in the design team, and I think most people accept that when model exchanged, you can't maintain ownership of that information, unless you put watermarking of some sort. Therefore implementing contractual obligation to identify the

> nature of copyrighted work and register it motivates collaborative work between project parties."

Interviewees turned to be in full accord with the influence of copyright principle on collaboration and stressed how imperative to implement such liability.

- Professional Negligence

The interviewees considered the standard of care and legal obligation to conform to a generally recognised and accepted industry practices to be a pragmatic approach that influence collaboration positively.

All interviewees agreed that the obligation to ensure conformance with plans and specification and develop fit-for-purpose design enhance collaborative work. In doing so, project parties will be motivated to implement strategies and develop capabilities to share and coordinate information. This, in turn, prevents professional deviation from standards and associated defective works.

A participant from service design consultant (SC-01) stated:

> "The implied warranty that service providers should always deliver proper workmanship and reasonable fitness for purpose requires is essential for good collaboration. It is a given thing that no one is expected to be negligent."

- Admissibility of Evidence

Interviewees considered digital technologies and the transition into an era of digital information is progressing rapidly. All firms described the growth of digital information networks as exponential and questioned the capability of a traditional legal system to adopt into such development that doesn't stop at jurisdiction boundaries.

A participant from a contracting company (C-03) argued that:

> "It is anticipated that the rapid change in digital environment will result in legal anomalies and ambiguities, therefore can't assume that everything can simply go in the new digital world, unless the existing conventional legal system which is slow to change perceives the benefits of technology and adopt changes."

Another participant from a design consultancy (EE-01) firm stated:

> "Progressing from drawings in CAD and specifications to the digital world as documentation referring to BIM plans is only a matter of time that admissibility of evidence will be considered in all court cases."

These statements were corroborated by all other interviewees, and the interviewees exhibited concerns about copyright, patent law and admissibility of electronic documents such as emails in courts as major factors that impact collaboration work.

A project sponsor (PS-01) stated:

> "Digital engineering is establishing itself as the most likely mechanism that any project parties will use to share and coordinate information between them. The legislative framework need to take into account of and adjust to the ongoing technology update"

- Data Authentication

All firms considered that authentication and identification of data is essential while transmitting various revisions of design-related information between project teams. A participant from a contracting company (C-03) stated:

> "with technology support, data can be audited to make sure it falls within the criteria set up in the BIM plan, properly authenticated to trace the right version and corresponding author."

Interviewees identified the legal barrier of authentication as a condition precedent to admissibility in courts. There was an agreement that the ability to authenticate data enhance the effectiveness and quality of collaboration working situation. Transmitting wrong or incomplete information could cause disputes which can easily be resolved if technology and obligation to support authentication exist.

A participant from a project management consultancy (PM-03) stated:

> "Legal and contractual obligation to ensure accuracy and completeness of information, facilitate a better environment for team members in a collaborative environment."

- Unauthorised Use of Data by Others

Confidence and trust between the contracting parties limit collaboration barriers. Interviewees shared relatively similar view that protection of confidential information is a general law principle even if the contract doesn’t exist. A structural engineer from a design firm (SE-01) clarified:

> “To motivate collaboration and sharing of information, parties should be under an obligation of confidence to control the use and disclose of confidential information. “

This triggered another comment from a client representative representing a private developer (CR-01) who argued that:

> “Legal protection for any confidential information could be sought through common law or contract law provisions; however project parties remain liable to ensure the secrecy of their sensitive information.”

Interviewees then reach into a consensus around a comment made by an architect (A-01) who said that:

> “Security is a major concern, and it is related to sensitive information and also BIM digital data in general. Lack of legal consideration represents a drawback which need to be adequately addressed. Adopting governance framework is needed to facilitate data protection and hence team collaboration”.

Confidentiality agreements, adequate record of what is considered to be sensitive information, and secured access procedure are all part of the governance framework.

7.4.3 Technology

Technology provides mechanisms and medium for collaboration between teams allowing information sharing and coordination across time and organisational settings. Sustained adoption of BIM requires sufficient IT infrastructure of hardware and software capability for the teams to effectively undertake their technical tasks.

Collaborative technologies facilitate efficient communication between teams, albeit dependent on how they are implemented. Interviewees clarified that among other things, privacy, accuracy and richness of information influence collaboration and hence the quality of end product. However, for the technology to be commercially successful, legal protection need to continue evolving to protect intellectual property rights.

Below themes (Figure 7.4) are extracted from Nvivo 12 based on the interviewees' feedback which illustrates the technology component and its associated variables

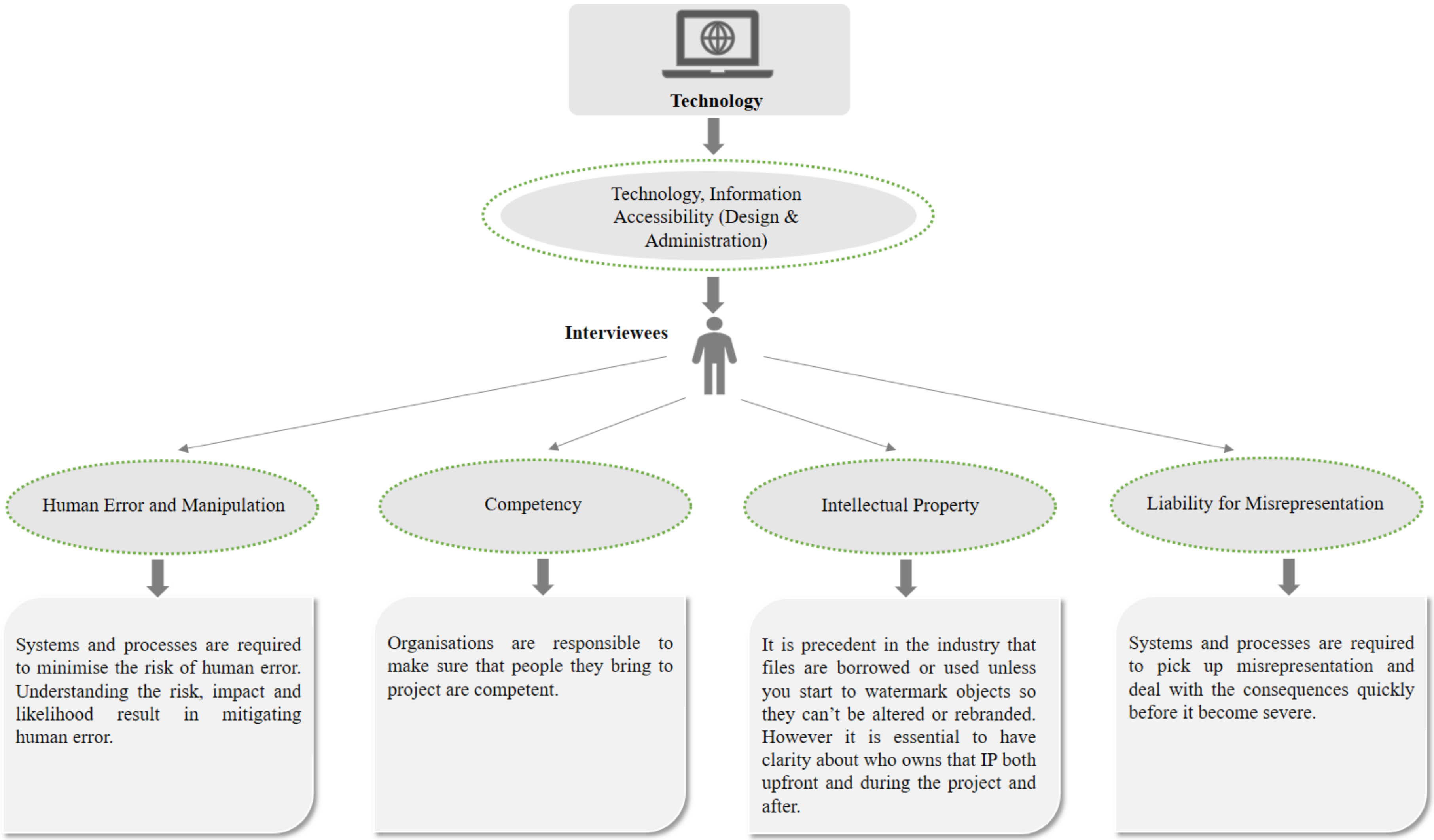


Figure 7. 4 Technology: main and sub-factors of collaborative work

- Human Error and Manipulation

The implied warranty and negligence, whether in design or construction, is a liability that needs to be addressed. Defective and unreasonably dangerous product amount to negligence. Design teams are liable to deliver a safe product, which subsequently entails to investigate the likelihood of human error, and associated foreseeable risk.

The discussions converged to identify another collaboration barrier as reported by a participant from a design consultancy (ME-01) who said:

> "Relying on the absence of human error is lack of reasonable care in the design. Designers should always exhaust options for a safe alternative design to avoid risks of injury".

This was corroborated by another participant from a contracting company (C-01) who said:

> "We need systems and processes to avoid the risk of human error and minimise the impact if it happens. However, mistakes happen and therefore clear and straight forward way of resolving the consequences is important as well. It is also important that project parties understanding the risk assessment, the likelihood and impact and how to mitigate that"

- Competency

Team members are expected to bring forward and share their experience, skills, and knowledge in a collaborative work approach. Factors such as motivation, previous successful experience of working together enforce such expectation. Competency and experience controls the social interaction between team members and hence the possibility to collaborate and build trust.

Organisations are expected to use reasonable care in appointing team members to avoid liability of incompetency. All interviewees shared the understanding that competency is a collaboration enabler; organisations need to support training and continuing professional development regimes and make them available to their staff. A participant from a design consultancy firm (ME-01) stated that:

> "Competency covers not only BIM or digital models but it comes back to the competency of organisations to provide skilled BIM modellers. The responsibility comes back to the team to make sure that people they bring to the job are competent."

Another participant from a project management firm (PM-01) also stated:

> "Competency includes skills, knowledge, traits and behaviours. The competency of team members largely determines the possibility of a project team to achieve their objectives. Project parties in a collaborative work need to be liable to appoint competent individuals for the required functions and tasks and to ensure achieving an effective performance."

- Intellectual Property

Copyrights and patents are the cores of the intellectual property landscape. The registered owner of a design is the owner of an eligible layout who is permitted by law to produce, reproduce or share what might be categorised as intellectual property (Joyce et al., 2016).

A project sponsor (PS-01) argued that:

> "The important part about IP is whether something of unique value is being created or built. Organisations need to assess such a question just like other risks that they probably would assess upfront. The lesson learned over the years confirms that not just upfront assessment is required but also to have reminders while progressing with work stages to ask the same question; have we created anything with IP worth protection and how it is managed by the organisation and the arrangement around the usage of that property. At the closeout of the project, you need to make sure you have appropriate treatment for any IP that is recognised by the organisation, how it is stored and managed on an on-going basis. Another essential issue is to have clarity about who owns that IP both upfront and during the project and after."

There was an agreement that establishing copyright ownership is the initial step that all parties should take prior to enter into the project to ensure their entitlement for copyright protection. Subsequently stipulate if license to copy works exist. Such license would overcome any liability for infringement if a party copied another party's work. Such protection measures facilitate collaboration and motivate teams to share their design data without reluctance. This assumption was corroborated by an architect (A-01) who said:

> "It is precedent in the industry that with CAD software, we share files so frequently and it is given that such files are borrowed or used unless you start to watermark objects so they can't be altered or rebranded."

- Liability for Misrepresentation

The reliance on misrepresented statement could result in damages that ruin any effort for cooperative work. Misrepresentation made by any project party vitiates their entitlement under the contract and hold them liable for fraudulent and violation of consumer act.

Fundamentally all interviewees believed that any misleading or deceptive conduct amount to misrepresentation which in turn hinder all efforts to build trust, stimulate teamwork and develop collective work environment. Misrepresentation is a major collaboration barrier that project parties should regulate in their contract.

> "The best you can do is to have systems and processes to pick misrepresentation up and to be able to deal with the consequences quickly before that become severe. Unfortunately, the governance system of most organisations is ineffective in deterring such misconduct; therefore, regulatory intervention is needed."

7.5 Chapter Summary

It has been acknowledged that the construction industry is highly fragmented and adversarial. For the past five decades, legitimate field of study, worldwide, confirm the attempts to enact change within the industry through addressing the fault finding and defensiveness attitude that lead to litigation. There has been growing consensus that collaboration and communication are the core issues that need to be improved in the construction industry. As a result, various types of collaborative procurement methods and contract forms have been presented and become popular in construction such as Alliances, Joint Ventures and Integrated Project Delivery.

Innovations in technology such as Building Information Modelling (BIM) enables project parties to spatially coordinate in three dimensional (3D) space throughout the various stages of development, and hence better management of change. BIM emerged as core enablers to facilitate collaboration and communication because of its robustness and usefulness in synergising the information required to design, construct and operate, and to model and simulate a variety of scenarios. However proper implementation of BIM requires governance and collaboration framework that addresses issues such as lack of trust, information ownership and Intellectual Property Rights, and issues related to data accuracy, errors and liability for incomplete or wrong data. The ability to enact collaboration is stymied because the underlying contracts and traditional legal structure remain adversarial

An interpretivist approach that relies on key informant interviews has been applied for this research. A total of 15 semi-structured interviews were conducted with experts of various engineering disciplines. The conceptual governance-based collaboration framework, which was developed earlier and discussed in chapter 5, has been presented to all participants. It was identified that quantum level of collaboration and interaction is needed between stakeholders in BIM-enabled projects. All contracting parties are required to sort through catalogues with large volumes of information, use stored data about available products and associated technical analysis to provide other users with the most relevant information and enable multiple of vendors to further contribute with other information.

All interviewees exhibited an explicit agreement that the proposed core dimensions of collaboration and associated variables influence collaboration and the ability of project parties to engage actively in a collaborative BIM environment. The nexus between the identified collaboration dimensions and the attainment of BIM was made explicit.

Interviewees revealed that the change surrounding collaborative processes and workflow in the context of BIM need to be recognised and project teams understand how and why information needs to be managed, monitored, controlled and shared throughout the project lifecycle.

The exploratory study presented in this chapter is significant for this research because the proposed framework identifies the interactions between collaboration dimensions and variables that can be used by organisations to build a new structure that would improve their collaborative performance.

Below themes are extracted from Nvivo 12 based on the interviewees' feedback which illustrates the main components and associated factors that are prerequisite for collaboration.

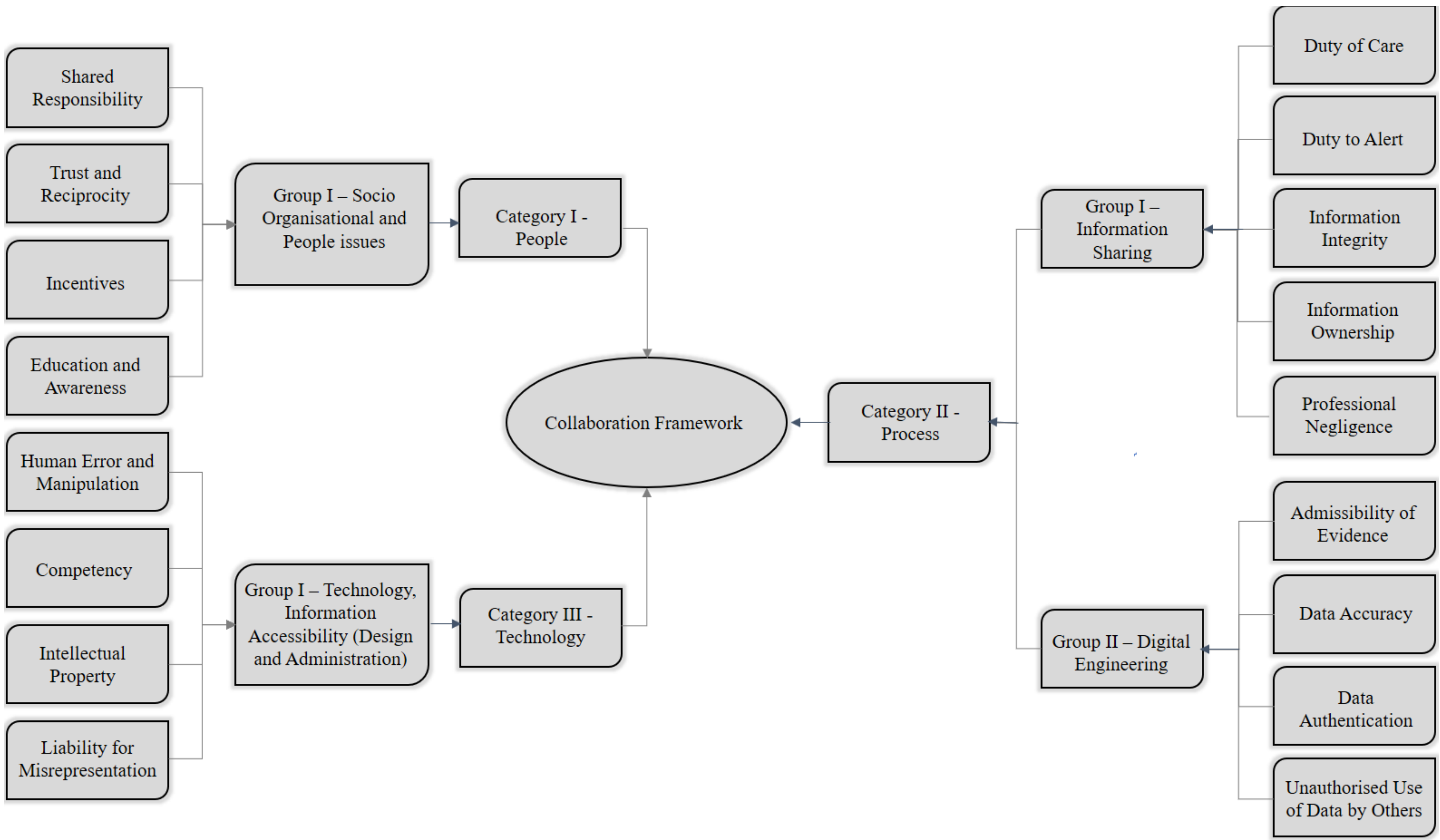


Figure 7. 5 Collaboration core dimensions and associated variables – overall view

CHAPTER 8 DISCUSSION

8.1 Chapter Introduction

Collaborative governance framework has become a common term in administration literature, yet its application still needs exploration in the context of legal issues and notions of claims. This research addresses the limitations associated with the previous study of collaborative governance. It presents a conceptual framework that takes into consideration industry literature and reports concerning BIM legal and claims issues, published court reports, and how court have dealt with technological changes in the construction industry. Such consideration makes the framework broader than what is commonly seen in the literature

The proposed framework is integrative. It combines the core dimensions of collaboration and organises variables into clusters; therefore, it enables further analysis of the internal dynamics and causal pathways of collaborative governance and its performance. BIM is a complex collaborative process, where each contribution supports the whole team practice and not only each of the project stakeholders. Therefore the developed framework provides a clearer understanding of the intersection of collaboration and governance needed to support the adoption of BIM in construction.

Aiming at looking across various research lenses to see how they might inform collaboration governance, a broad array of literature was explored. The literature included work in many different applied fields, such as collaboration definitions, collaboration theories, construction claims, conflict management, organisational issues, data loss and archiving, and technologies. The literature also included relevant conceptual frameworks that were grounded in empirical studies.

Further to the literature review, an interpretivist approach that is based on semi-structured interviews was conducted. The interviews helped inform and refine our a priori assumptions about the categories and variables in the integrative framework and helped to identify the perils associated with each variable. Examples of court judgments were used to address the opportunities and constraints that influence the dynamic of collaboration.

8.2 Collaboration framework

BIM is a collaborative undertaking and, it requires partners to structure their processes. The overall process must consider design development and include the right profession at the right time. Owners, architects, engineers, contractors and suppliers must break with their cultural behaviour when performing a construction task to benefit from each other's effort. Therefore, BIM's success depends on the ability to structure the project flow, using the right type of expertise and software to evolve the LOD of the project strategically.

Information captured in this research has been structured and consolidated in a collective framework (Figure 8.1). As illustrated in the framework, the core dimensions of collaboration (People, Process and Technology) share one common area (intersection area 4), which is identified as an appropriate location for optimal collaboration. Stakeholders must utilise each other's effort to maximise that common area and achieve optimal collaboration during the use of BIM. The conceptual framework also denotes other collaboration components and associated prerequisite variables. Intersection areas 1, 2 and 3 refer to the existing level of coordinative interactions between organisations where assistance is always needed to accomplish common goals. As discussed in Chapter 6, the prerequisite variables have been legitimised using precedents from case-laws which facilitate the possibility to incorporate into the contractual relationships between team parties.

Building and engineering contracts are often entered into based on standard form contracts created by bodies such as the Joint Contracts Tribunal (JCT), institution of Civil Engineers (ICE), the SBCC (Scottish Building Contract Committee), the FIDIC (International Federation of National Associations of Independent Consulting Engineers), (NEC) the New Engineering Contract, AS (Australian Standards) 2124-1992 and AS 400-1997.

Mutual trust and cooperation form part of all standard contracts where all stakeholders are obligated to act in a spirit of mutual trust and cooperation. The objective of this clause is to motivate the Contractor, the Owner, the Project Manager and the Supervisor to work together for the benefit of the project. However as discussed in Chapter 5, AEC sector is notoriously risk-averse, and organisations are not yet prepared to work together on trust only but sought to protect themselves through contracts and other legal documents governing their working relationships. In the case of *Phillips Petroleum Company UK Ltd & anor vs. Enron Europe Ltd*, (1996), the plaintiff had agreed to sell natural gas to the defendant. As a prerequisite for the sell, the plaintiff had to construct a gas pipeline from its fields to the defendant's on-shore facilities while the defendants were to construct the receiving facilities for the gas. Because both projects were interdependent, the agreement required both parties to coordinate their construction schedules and use 'reasonable endeavours' to agree in advance to commission the projects together. Because of changes in the commercial value of the project caused by a fall in the price of gas, the defendant refused to agree to a commissioning date, arguing that the agreement to work together was an agreement to agree and therefore unenforceable. The court, while acknowledging the general rule on the unenforceability of agreements to agree, found that in the circumstances of the case, a refusal to agree was inconsistent with the requirement to use reasonable endeavours. The plaintiff, therefore, had a cause of action.

Aiming to bring separate organisations together to work within and across boundaries, mandated relationships are needed. Nylen (2007) refers to mandated relationships as "professional collaboration" (p.145). Lovell and Tobin (1981) define a mandate as "any responsibility, procedure or other activity that is imposed on one government by another by constitutional, legislative, administrative, executive, or judicial action as a direct order, or as a condition of aid" (p.60)

The following sections will investigate collaboration in the context of standard contract forms. Various variables influence optimal collaboration that BIM requires; therefore, appropriate contractual provisions must be made to address the legal concerns and achieve optimal collaboration between the relevant project participants.

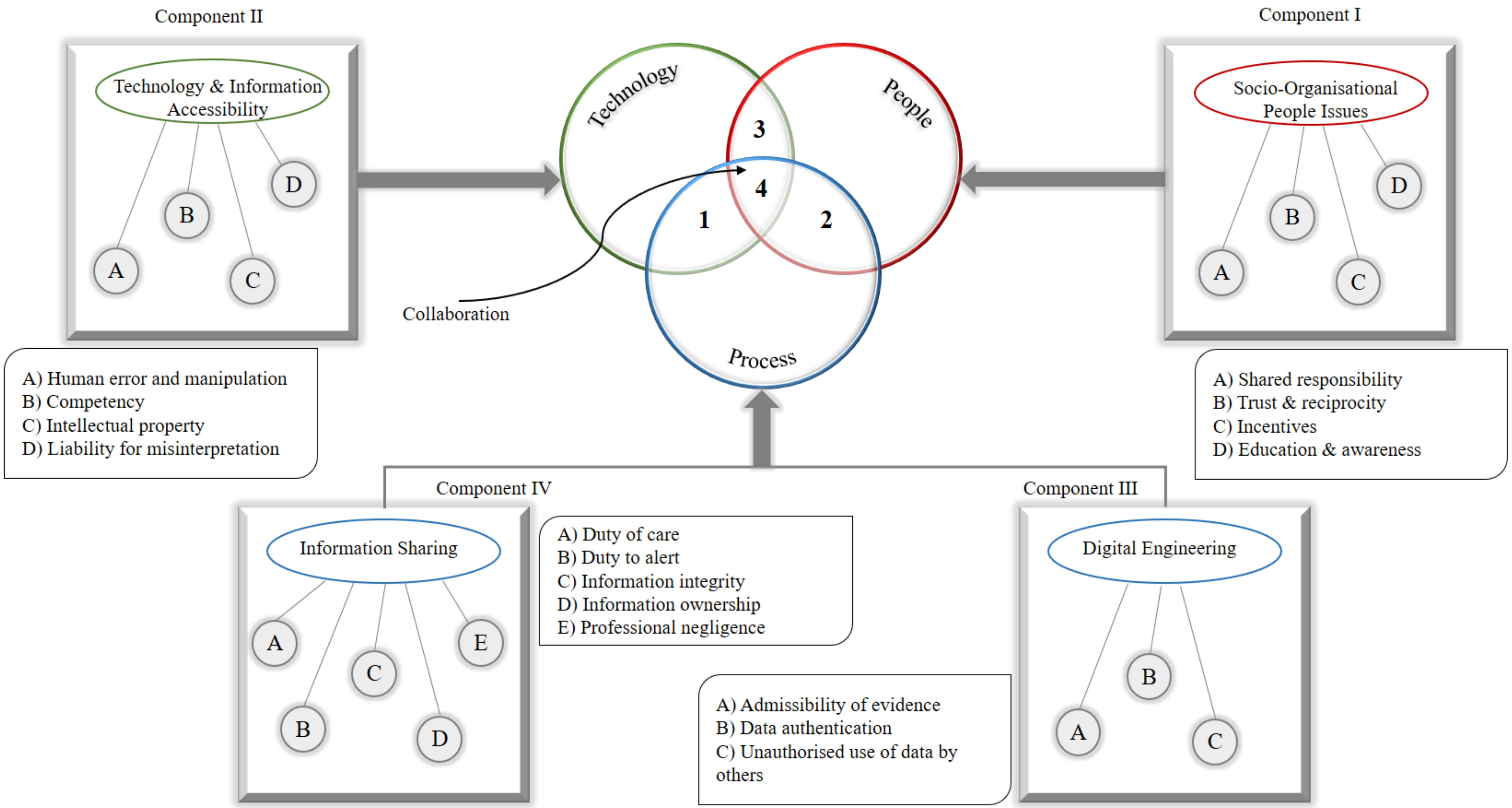


Figure 8. 1 Collaboration - conceptual framework

8.3 Research Implications - Socio-Org. and People Issues

Optimal collaboration within BIM project teams relies on each parts willingness to operate on behalf of each other. However, architects, engineers, contractors and suppliers cannot expect each other to understand the individual needs for building information along the project design development. Therefore creating a common understanding on how to communicate for better collaboration is the goal. As discussed in Chapter 6, considerations concerning the variables associated with socio-organisational component are needed and contractual clauses imposed into the existing contract forms to obligate contracting parties to collaborate and, hence benefit the overall collaborative process of BIM properly.

8.3.1 Shared Responsibility

Standard forms of contract incorporate provisions to emphasise obligations and entitlements of each contracting party clearly and separately. No provision is stipulated to support shared liability. Relevant clauses from two different standard contracts are highlighted below to discuss the contractual effect and associated consequences:

JCT

- Clause 2.1 - General Obligations

  "The contractor shall carry out and complete the works in a proper and workmanlike manner and in compliance with the contract documents, the construction phase plan and other statutory requirements and for that purpose shall complete the design for the works including the selection of any specifications for the kinds and standards of the materials, goods and workmanship to be used in the construction of the works so far as not described or stated in the Employer's requirements or contractor's proposal and shall give all notices required by the statutory requirements."

FIDIC (Red Book 1999)

- Clause 4.1 – Contractor's General Obligations

  "The contractor shall design (to the extent specified in the contract), execute and complete the works in accordance with the contract and with the engineer's instructions, and shall remedy any defects in the works."
- Clause 1.14 – Joint and Several Liability

“If the contactor constitute (under applicable laws) a joint venture, consortium or other unincorporated grouping of two or more persons; these persons shall be deemed to be jointly and severally liable to the employer for the performance of the contract.”

Standard contracts need amendments to accommodate the understanding of shared liability as opposed to a single point of responsibility. Shared liability motivates parties to work together to deliver a project or series of projects, to reduce disputes, avoid confrontational behaviour and to reject inappropriate commercial or legal advantage. The RIBA’s Guide to Sound Practice (Cox, 2002) refers to collaborative efforts as “..all partners should benefit from the success of their collective efforts and conversely be prepared to share the consequences of failure.”

8.3.2 Trust and Reciprocity

The Housing Grants, Construction and Regeneration Act 1996 (HGCRA) in the UK lays out special rules concerning construction contracts; rules which have as their central focus, the principles of fairness and good faith. The Construction (Design and Management) Regulations (CDM) refers to the cooperation between all members of the project team as imperative, and states that everyone must seek the co-operation of any other person concerned in any project involving construction work at the same or an adjoining site so far as is necessary to enable himself to perform any duty or function under the regulations. Reference to cooperation is mentioned in FIDIC Conditions of Contract for Works of Civil Engineering Construction First Edition 1999, and as below:

FIDIC (Red Book 1999)

- Clause 4.6 – Co-operation

“Contractor liability to co-operate and allow appropriate opportunities for carrying out the work is contingent on the contract terms and conditions, otherwise as instructed by the architect, however, subject to a variation if the instruction to co-operate results in unreasonable cost.”

The lack of promoting interactional norms in construction contracting, resulted in a general industrial climate where caution, hesitation and, even conflicting relationships are the normal rules of engagement. Therefore to improve the harmony in contractual relationships, contracts need to include norms that stress "mutual trust and cooperation." to motivate collaboration. In addition to the focus on techniques and practices to align parties' commercial approaches such as partnering and pain/gain share arrangement

8.3.3 Incentives

Performance incentives is another factor that motivate team parties to collaborate. Organisations in which employees are rewarded for their performance are likely different from those in which there are few incentives. Pasquire et al. (2011) argue that incentives create circumstances where cooperation better serves team parties' economic interest and clarify that performance deemed to be motivated by trust-based incentives more than mandatory incentives. Standard forms of contracts include no provisions to incorporate incentives; however, a non-binding project charter or addendum has been drafted for use in establishing relational norms.

The JCT introduced the Constructing Excellence Contract (CE), which has an optional addendum, the Constructing Excellence Contract Project Team Agreement (CE/P). The NEC also has a non-binding charter (the Option X12), which can be used in conjunction and also to involve other project actors.

The issue of emphasising relational norms in construction contracts is essential, and incentives need to be explicitly stated and addressed in an incentive program. Clauses to that end need to be incorporated as terms and conditions within the underlying contract between the parties.

8.3.4 Education and Awareness

Successful collaboration will require organisations to develop relationships that go beyond the standard operating procedures and planning processes. Education and competence development become a central factor in stimulating collaboration performance. Organisations need to adopt a culture that foster motivational climate and facilitates entering into collaborative relationships. As discussed in Chapter 6, education contributes to culture change, and hence the willingness to interact collaboratively. Sharing information about the perceived criteria of success and failure is essential and beneficial for organisations to enhance cohesion and collaboration in teams. The reference to share project update among team parties, and duties of certain team members is included in the standard forms of contact such as:

FIDIC (Red Book 1999)

- Clause 4.21 – Progress Reports

"Unless otherwise stated in the particular conditions, monthly progress reports shall be prepared by the contractor… reporting shall continue until the contractor has completed all work…. each report shall include clear and detailed description of progress, including each stage of design (if any), contractor's documents, procurement, manufacture, delivery….)

- Clause 4.3 – Contractor's Representative

"The contractor shall appoint the contractor's representative and shall give him al authority necessary to act on the contractor's behalf under the contract."

- Clause 3.1 – Engineer's Duties and Authority

"The employer shall appoint the Engineer who shall carry out the duties assigned to him in the contract. The Engineer's staff shall be suitably qualified enigneers and other professionals who are competent to carry out these duties."

Contract forms require further provisions to stipulate the responsibilities and authorities for all other team members such as designers, and associated processes.

8.4 Research Implications - Technology and Info. Accessibility

The information-sharing process is needed to manage the conveyance of information among multiple parties in BIM-enabled project. Team members of various engineering disciplines should access the information at different stages and be able, for example, to retrieve a plan from the server and identify the source of that plan. Therefore database of user information, which includes identification code associated with each computing device, is needed. All users must be able to share information through that network.

In the case *Perdiem Co, LLC vs. IndusTrack LLC,* (2016) information sharing system was construed as:

"Information sharing system.", "information sharing environment/s", and "location information sharing environment/s" to mean "a computing network where the conveyance of information from a server to a group of users' computing devices can be controlled as confirmed."

Technologies to automate, speed up the process, and prevent human error and manipulation are needed to facilitate the required information-sharing process. Besides, team members are required to possess competence and exhibit reasonable care when obtaining and transmitting information. The provision of wrong information amounts to liability for pecuniary loss.

8.4.1 Human Error and Manipulation

As discussed in Chapter 6, an obligation is placed by law on the side of designers to consider human error. The consequential damage of human error amounts to design negligence. Standard forms of contract highlight the responsibility of the contractor to comply with CDM regulations (The Construction Design and Management Regulations) when carrying out an agreed on design portion. CDM regulations stipulate that foreseeable risks to the health and safety of any person shall be avoided when preparing or modifying a design which may be used in construction. Below provisions extracted from standard forms of contracts and as follows:

JCT

- Clause 2.2 – Contractor's Design Portion

"where the works include a contractor's designed portion, the contractor shall… complete the design for the contractor's designed portion… and comply with CDM regulations."

- Clause 2.13 – Preparation of Contract Bills and Employer's Requirements

"… the contractor shall not be responsible for the content of the employer's requirements or for verifying the adequacy of any design contained within them."

- Clause 3.23 – CDM Regulations

" each party acknowledges that he is aware of and undertakes to the other that in relation to the works and site, he will duly comply with the CDM regulations."

FIDIC (Red Book 1999)

- Clause 4.1 – Contractor's General Obligations “the contractor shall design, execute and complete the works in accordance with the contract and with the engineer’s instructions, and shall remedy any defects in the works.”

- Clause 17.2 – Contractor’s Care of the Works

“The contractor shall take full responsibility for the care of the works and goods from the commencement date until the taking-over certificate is issued or is deemed to be issued.”

In light of the above, consideration to compensate for the risk of human error is not included in the contract forms expressly. Although the obligation to develop a design that is free of risk is stipulated in various clauses, the wording needs to be amended to depart from the adversarial nature. Other team parties such as the architect and other designers need to share the liability for safe design to enhance the collaborative behaviour.

8.4.2 Competency

The standard forms of contract highlight competency and skills. Different provisions stipulate the requirement to appoint qualified staff. Clauses listed below are extracted from FIDIC (Red Book 1999) and as follows:

- Clause 3.1 – Engineer’s Duties and Authority

“ The employer shall appoint the engineer who shall carry out the duties assigned to him in the contract. The engineer's staff shall be suitably qualified engineers and other professional who are competent to carry out these duties.”

- Clause 4.3 – Contractor’s Representative

“The contractor shall appoint the contractor’s representative and shall give him all authority necessary to act on the contractor’s behalf under the contract….. the contractor shall prior to the commencement date, submit to the engineer for consent the name and particulars of the person the contractor proposes to appoint as contractor's representative.”

- Clause 4.3 – Contractor’s Personnel

“The contractor’s personnel shall be appropriately qualified, skilled and experienced in their respective trade or occupations.”

As highlighted above, the standard forms of contract refer to the contractor and client representative "The Engineer" and emphasise the requirement to have qualified staff allocated to the project team. However, no specific mention pertinent to the architect and other service consultants is made. This gap needs to be addressed to ensure that all team parties are suitably qualified and possess the necessary competence that would motivate the collaboration that BIM requires.

8.4.3 Intellectual Property

Copyright and intellectual property protect the expression in material form of ideas or information (Stewart et al., 2018). Copyrights arises when any entity exercises originality in creating a literacy, dramatic, or artistic work. Designs are typically derived from artistic works; therefore, it is imperative to address the interrelation between design and copyright protection. Provisions for patent and intellectual rights are allowed for in the standard forms of contracts. However, such provisions mainly refer to the infringement liability with no reference to any measures to protect the patent rights. Clauses below are extracted from JCT and FIDIC and as follows:

JCT

- Clause 2.23 – Patent Rights - Instructions

"Where in compliance with the architect/contract administrator's instructions the contractor shall supply and/or use in carrying out the works any patented articles, processes or inventions, the contractor shall not be liable in respect of any infringement or alleged infringement of any patent rights concerning any such articles, processes or inventions and all royalties, damages or other sums which the contractors may be liable to pay to the persons entitled to such rights shall be added to the contract sum."

- Clause 2.41 – Copyrights and Use

"1- Subject to any rights in any design, drawings and other documents supplied to the contractor for the purpose of this contract by or on behalf of the employer or the architect/contract administrator, the copyright in all contractor's design documents shall remain vested in the contractor.

2-Subject to all sums due and payable under this contract to the contractor having been paid, the employer shall have an irrevocable, royalty-free, non-exclusive licence to copy and use the contractor's design documents and to reproduce the designs and content of them for any purpose relating to the works…but shall not include licence to reproduce the designs contained in them for any extention of the works."

FIDIC (Red Book 1999)

- Clause 17.5 – Intellectual and Industrial Property Rights

"the employer shall indemnify and hold the contractor harmless against and from any claim alleging an infringement which is or was:

a- an unavoidable result of the contractor's compliance with the contract, or
b- a result of any works being used by the employer

the contractor shall indemnify and hold the Employer harmless against and from any other claim which arises out of or in relation to (i) the manufacture, use, sale or import of any goods, or (ii) any design for which the contractor is responsible."

The existing contract forms do not refer to contractual relationship between stakeholders where intellectual property rights are owned. Well-drafted contractual provisions are required to ensure that stakeholders are not avoiding liability for infringement unreasonably. Absence of such conditions and clauses would seriously affect collaboration.

8.4.4 Liability for Misrepresentation

The cooperative or competitive motivation influences the tendency to provide accurate or inaccurate information. Project parties experience mixed-motive interdependence. (Steinel & De Dreu, 2004) clarify that cooperative incentives motivate individuals to be truthful and work together, while competitive incentives increases the perception of personal gains. Existing contract forms are silent about the misrepresentation liability. References are limited to contractor's liability to provide accurate setting out data and as listed below:

JCT

- Clause 2.14 – Contract Bills and CDP Documents-Errors and Inadequacy

"Any error in description or in quantity in the contractor's proposals or in the CDP analysis or any error consisting of an omission of items from them shall be corrected."

FIDIC (Red Book 1999)

- Clause 4.7 – Setting Out

"The contractor shall set out the works in relation to original points, lines and levels of reference specified in the contract or notified by the engineer. The contractor shall be responsible for the correct positioning of all parts of the works."

Collaboration facilitates a working environment that is conducive to the exchange of accurate information and hence high collective outcomes as opposed to the use of misrepresentation and associated self-interest, and personal outcomes. Contractual provisions are required to prevent noncooperative tendencies that may be reflected in withholding information or in focused misrepresentation explicitly aimed at misleading the counterpart about the structure of the decision-making task.

8.5 Research Implications - Digital Engineering

The astronomical pace of technological innovation entails an alternative medium of communication. Electronic means are required to capture, structure, transfer, and store, and make available information when needed. General confidence and trust need to be built in the electronic means as an accepted method of communication. Organisations exhibit general hesitancy in the use of electronic environment, however, the essential factor is that adequate safeguards are needed to protect all stakeholders.

Organisations in BIM-enabled projects are seamlessly linked via digital information. State-of-the-art technology is utilised to facilitate access to a wide range of computer-based communications and productivity tools. Internal collaboration and communication are enabled through web-based technologies. However, the uncertainty regarding the legal status of electronic communications resulted in delaying decisions about collaboration systems. However, the court in the case *Precision Piping and Instruments vs E.I. du Pont de Nemours and Co., 951*

F.2d 613, 621, (1991) held that all documents supporting the facts must be admissible in evidence in case of any dispute between parties

8.5.1 Admissibility of Evidence

Relevance is not a static concept and not an inherent characteristic of any evidence. The tendency of evidence to prove or disprove a consequential fact in the litigation is sufficient to achieve relevancy; therefore, a particular weight for the evidence is not relevancy prerequisite. In the case *United States vs Safavian, 435 F. Supp. 2d 36, 41-42,* (2006), during a preliminary investigation about the admissibility of emails, government lawyers compiled statements from FBI agents to support their presentation. The trial Judge alerted that witnesses with personal knowledge of facts would be called for as opposed to rely on FBI agent's testimony merely. Meeting the threshold of relevance ensures the admissibility of evidence, unless the constitution, a statute, rule of evidence or procedure, or case law requires that it be excluded.

The exchange of information in construction work has become progressively more widespread through the use of electronic means. Therefore concerns pertinent to the admissibility of documents other than "in writing" such as by email, ftp sites or the like exist. Standard form of contracts require participants to issue formal notices in writing and not always clear whether electronic communications will suffice.

JCT

- Clause 1.7 –Notices and Other Communications

"Any notices or other communication between the parties, or by or to the architect/contract administrator or quantity surveyor, that is expressly referred to in the agreement or these conditions (including, without limitation, each application, approval, consent, confirmation, counter-notice, decision, instruction or other notification) shall be in writing"

FIDIC (Red Book 1999)

- Clause 1.3 – Communication

"in writing and delivered by hand (against receipt), sent by email or courier, or transmitted using any of the agreed systems of electronic transmission as stated in the appendix to tender"

Existing contract forms need additional provisions to allow for electronic transmission of documents via an agreed-on system. Such amendments will make the contracts appropriate for online collaboration and to enable team members to communicate electronically. In addition, rigorous audit trail to associate with any created document is required to ensure document authenticity, and hence admissibility of evidence in courts if in case is needed.

8.5.2 Data Authentication

The authentication of electronic information may require greater scrutiny as opposed to paper-based information. Courts emphasised concerns regarding the accuracy and authenticity of computerised data. Accuracy may be impaired by incomplete data entry, mistakes in output instructions, programming errors, damage and contamination of storage media, power outages, and equipment malfunctions. Improper search and retrieval of information could compromise the integrity of data. In the case *Indianapolis Minority Contractors Ass'n. Inc. vs. Wiley, 1998 U.S. Dist. LEXIS 23349, 1998 WL 1988826*, (1998), establishing that the process or system produces an accurate result was a condition precedent to the admissibility of computer records.

The distinctive characteristics of an email message include its content, pattern, and substance, in combination with circumstances, could meet the authentication requirements. Emails could be self-authenticating if it contains signature and information confirming the origin of the transmission. However, the potential for unauthorised transmission remains possible since email can be sent to any person other than the named sender. Therefore testimony from the sender or receipt to ensure its trustworthiness is required to confirm the authentication of emails.

Technology evolves so rapidly that there is no single approach to authenticate electronic evidence. Lindblad and Vass (2015) clarify that collaborative workflow is required to facilitate the implantation of BIM in construction, which can only be accomplished through change management strategy (Vass & Gustavsson, 2017).

Existing contract forms allow for no electronic transmission of information. Instruction if not in writing shall be of no effect until after it has been confirmed in writing as stated below:

JCT

- Clause 3.12 – Instructions other than in Writing

"Where the architect/contract administrator issues an instruction otherwise than in writing, it shall be of no immediate effect but the contractor shall confirm in writing to the architect/contract administrator with 7 days, and, if he does not dissent by notice to the contractor within 7 days from receipt of the contractor's confirmation, it shall take effect as from the expiry of the latter 7 day period."

FIDIC (Red Book 1999)

- Clause 3.3 – Instructions of the Engineer

" the engineer may issue to the contractor (at any time) instructions and additional or modified drawings which may be necessary for the execution of the works and the remedying of any defects, all in accordance with the contract. The contractor shall only take instructions…… the contractor shall comply with the instructions given… whenever practicable, their instructions shall be given in writing."

Therefore since collaboration in BIM-enabled projects requires electronic transmission of information, it would be prudent to consider appropriate clauses to ensure the authentication of data transferred through the collaboration platforms.

8.5.3 Unauthorised use of data by others

In a collaborative environment, there must be specific provision made for the transfer of ownership of a data item as soon as it enters the collaborative environment. It would normally be expected that the client in a construction enterprise would be the ultimate owner of all the project data, although contractors sometimes take on this ownership and transfer it all to the client at hand-over. Depending on what terms of appointment or project protocols have been agreed, architects and other designers may be required to submit CAD drawings in their native format (e.g. Autocad files in DWG format), giving rise to concerns about unauthorised use of design drawings – and hence breach of copyright – based on a perception that an electronic system may be more prone to abuse than a paper-based one.

Subject to the availability of any technical measures to reduce the unauthorised use or alteration of documents, legal protection is best to obtain by ensuring that contracts contain appropriate, effective and explicit confidentiality and licence provisions. No specific provisions are allowed for in the existing contract forms other than what refers to the contractor's design portion and as follows:

JCT

- Clause 2.41 – Copyright and Use

"The contractor shall not be liable for any use by the employer of any of the contractor's design documents for any purpose other than that for which they were prepared."

FIDIC (Red Book 1999)

- Clause 1.10 – Employer's Use of Contractor's Documents

"The contractor shall retain the copyright and other intellectual property rights in the contractor's documents and other design documents made (or on behalf of) the contractor. The contractor shall be deemed to give non-terminable, non-exclusive royalty-free licence to copy, use and communicate the contractor's documents to complete, operate, maintaining, altering, adjusting, repairing and demolishing the works."

The aforementioned clauses grant a licence to the employer to use the contractor's design portion as per the contract and in relation to the specific project; however nothing is stipulated regarding the unauthorised access of data by others. Although there are instances where the final design may have been developed collaboratively, such collaborative design may be fairly rare. In addition, collaborative design represents the intellectual output of a g4roup as opposed to one individual or firm, and hence contractual clauses to protect the designers for having their design documents accessed without an authorised licence remain a necessity to ensure achieving the required collaboration.

8.6 Research implications - information sharing

Providing and sharing information among stakeholders could trigger the risk of patent infringement and ownership of data. Therefore to achieve optimal collaboration, the exchange of information requires method and system to set criteria to provide and store compatible and professional accessible information. It was established that the transfer and share of information needed to be monitored and recorded in the system for each stakeholder.

BIM is a joint invention resulted from the collaboration of the inventive endeavours of all parties. Its implementation requires organisations to work together and produce invention by their aggregate efforts.

8.6.1 Duty of care

Duty of care is imposed by law in the attorney-client relationship, where attorney shall be reasonably competent in protecting the best interests of his client inclusive legal services (see case *Georgetown Realty v. The Home Ins. Co., 313 Or 97, 106, 831* P2d 7, 1992). That duty is not only owed to the client but extends to include the intended beneficiaries (see case *Hale vs. Groce, supra, 304 Or at 284, 28*). An entitlement to recover economic loss results from breaching such duty of care. Engineers and architects are among those who may be subject to liability to those who employ or are the intended beneficiaries of their services and who suffer losses caused by professional negligence (see cases *Chocktoot vs. Smith, 280 Or 567, 570, 571 P2d 1255,* 1977*; Harding vs. Bell, 265 Or 202, 204-05, 508 P2d 216,* 1973*).*

A responsible approach to duty of care requirements is demonstrated in the existing contract forms which is evidenced in the following clauses:

JCT

- Clause 2.1 – Contractor's Obligations

"The contractor shall carry out and complete the works in a proper and workmanlike manner and in compliance with the contract documents, the construction phase plan and other statutory requirements, and shall give all notices required by the statutory requirements."

- Clause 2.17 – Divergences from Statutory Requirements

"If the contractor or architect/contract administrator becomes aware of any divergence between the statutory requirements and any of the documents referred to in clause 2.15, he shall immediately give the other notice specifying the divergence and, where it is between …, the contractor shall notify the architect/contract administrator of his proposed amendment for removing it."

FIDIC (Red Book 1999)

- Clause 1.13 – Compliance with Laws

"the contractor shall, in performing the contract, comply with applicable laws."

- Clause 4.1 – Contractor's general Obligations

"The contractor shall design (to the extent specified in the contract), execute and complete the works in accordance with the contract and with the engineer's instructions, and shall remedy any defects in the works."

As mentioned earlier, adequate contractual provisions are allowed for in the existing contract forms to record the duty of care liability. Although CDM regulations (The Construction Design and Management Regulations) stipulate the duties of designers, it would be best to include such clauses in the contract forms rather than in an external document.

8.6.2 Duty to Alert

The standard form of contracts highlight the duty of the architect/contract administrator to provide the contractor with the information that the contractor needs to progress with works. Such information includes the levels required for the execution of works and accurately dimensioned drawings. The architect/contract administrator is also obligated to provide the contractor with any further drawings or details necessary to explain and amplify the contract drawings. However, unless the contractor or architect/contract administrator becomes aware of any divergence between the statutory requirements and any of the contract drawings/bills, existing contract forms place no liability on the side of the contractor to verify the adequacy of any design provided by the architect.

Duty to alert related clauses are mentioned below:

JCT

- Clause 2.9 – Construction Information and Contractor's Master Programme

"The architect/contract administrator, without charge to the contractor, shall provide him with any descriptive schedules or similar documents necessary fo ruse in carrying out the works."

- Clause 2.12 – Further Drawings, Details and Instructions

"The further drawings, details and instructions shall be provided or given at the time it is reasonably necessary for the contractor to receive them."

- Clause 2.13 – Preparation of Contract Bills and Employer's Requirements

"Subject to clause 2.17, the contractor shall not be responsible for the contents of the employer's requirements or for verifying the adequacy of any design contained within them."

- Clause 2.17 – Divergences From Statutory Requirements

"If the contractor or architect/contract administrator becomes aware of any divergence between the statutory requirements and any of the documents referred to in clause 2.15, he shall immediately give the other notice specifying the divergence."

FIDIC (Red Book 1999)

- Clause 4.7 – Setting Out

"The contractor shall set out the works in relation to original points, lines and levels of reference specified in the contract or notified by the engineer. The employer shall be responsible for any errors in these specified or notified items of reference, but the contractor shall use reasonable efforts to verify their accuracy before ther are used."

The objective is to include contractual clauses that obligate all project parties to perform as a team, sharing the liability to alert for any suspected divergence. In collaboration platform, it is expected that all team members to be of adequate competency enable them to notify any defects in design. Joint liability enhances cohesion and task performance.

8.6.3 Information Integrity

In a collaboration system, appropriate legal arrangements must be put in place to support the integrity of data processed and stored on the system. Service interruption could be a source of disruption, requiring team members to change their working methods. Therefore, team members need to ensure that the integrity of the single central repository for all project data is not compromised. Standard form of contracts contain general provisions about information integrity; however, no protocol is stipulated for use by parties when communicating electronically. Information flow with adequate audit trails is needed for team members to perform in the collaboration environment. Contractual clauses are needed to stipulate the basic principles of information security management and set out the code of practice to be followed by team members while managing electronic data. Certification process will have a positive influence in determining the authenticity and accuracy of electronic documents throughout the project lifecycle.

8.6.4 Information Ownership

Sharing project information in an electronic collaboration environment raise concerns about the ownership, use, and possible abuse, of the information contributed by team members. Parameters to govern the use of project data by authorised project participants are needed. Such parameters include confidentiality, security and data protection, restrictions on the use of the collaboration system, copyright of collaboration technology, the use of the client's branding and data, and indemnification against misuse, unauthorised use, etc., of the collaboration system.

Ownership of the information also implies ownership of the environment. In the increasingly common case of the project extranet, there is currently still a degree of uncertainty among many participants as to the ultimate owner of the system; therefore an explicit statement of ownership should also be made. No specific clauses exist in the current contract forms other than what is related to patent rights, copyright and use clauses which were discussed earlier. Therefore it is imperative to impose rules and contractual clauses to control the ownership of information and facilitate the protection of drawings and other materials.

8.7 Chapter Summary

Organisations involved in one project intend to protect themselves through contracts and other legal documents governing their working relationships. However, concerns about legal issues have been cited as reasons for organisations to pick their way carefully through a still-evolving legal landscape. Decisions about using collaboration systems have been delayed because of legal uncertainty related to electronic communication, admissibility of evidence, and copyright. In addition to the legal uncertainty, collaboration is further challenged by the vague or non-existent of appropriate contractual provisions in the existing standard contract forms. The emergence of collaboration technology such as BIM has added further challenges to the construction industry where legal attention is required.

This research has identified various sets of collaboration variables and carefully examined their interrelationships. A conceptual framework was developed that encompasses the core dimensions of collaboration and how the variables of collaborative governance interact to shape events and outcomes.

Aiming to enable shared decision making, motivation, and joint action across organisations, Precedents from case-laws were used to discuss each variable from a legal perspective. Accordingly, describe the strengths and weakness, limits of applicability, and areas where we have the most and least empirical evidence. The existing standard form of contracts have been reviewed to investigate the current contractual provisions and investigate the possibility to include new clauses. However, the area of research is a still-developing and fast-changing legal area therefore appropriate professional advice is always needed before making firm commitment regarding the application of the research outcomes.

CHAPTER 9 Conclusion and Recommendations

9.1 Chapter Introduction

The research presented in this thesis aims to develop a novel governance-based framework, which incorporates the socio-organisational, process, and technology dimensions of collaborative work that is required to support BIM. With this primary aim, a qualitative line of inquiry to determine the contextual issues that engender collaboration in practice has been taken; therefore, 25 in-depth semi-structured interviews with a range of industry practitioners were undertaken to acquire an understanding of the issues influence the nature of collaboration in BIM-enabled projects.

A governance-based framework was developed that determines explicitly the fundamental collaboration principles that need to be incorporated into contracts to support the effective implementation of BIM. Then, using precedents from case-law, the core dimensions of collaboration that are identified are legitimised and, therefore, can be considered in conjunction with existing contract forms. Finally, to validate the developed governance framework, 15 in-depth semi-structured interviews were undertaken with practitioners. The developed conceptual framework is considered to be the most theoretically appropriate for satisfying the research objectives.

The major findings derived from the previous chapters, and the recommendation stemming from this research for future research, are summarised and reported in this chapter.

9.2 Collaboration in Construction

The background of this research and the necessity were examined in Chapter 1. The principal aim of this research, as addressed and emphasised throughout this thesis, was to make an original contribution to enhance collaborative works and hence, motivate the implementation and adoption of BIM in the construction industry. According to the primary aim, the relevant research objectives were proposed, and the structure of this thesis was explicitly described in Chapter 1. Research significance and potential contribution are also outlined in Chapter 1. Overall, this research is significant because it bridges the current gap in legal and contractual structures and provides the construction industry with a conceptual collaboration framework that can be considered in conjunction with existing contract forms.

Further, this is also the first research to be undertaken that used precedents from case-law to legitimise the core dimensions of collaboration and associated variables.

After providing an overview of the research, a review of the normative literature was presented in Chapter 2, providing an understanding related to the definition of collaboration and associated theories and frameworks. The review confirmed the importance and significance of a study of elements that are critical to the existence and success of collaboration and helped in identifying the main components of collaboration and the changes that organisations need to undertake to work in a collaborative environment.

An overview of BIM and the influence of collaboration on achieving its returns were presented in Chapter 3. Collaboration barriers, among other things, legal, technical and socio organisational challenges, and the importance to amend the existing contractual framework to motivate collaboration was also discussed in the context of scope of work, delay and work disruption.

9.3 Data Collection

The philosophical basis of the research methodology and its validity were described in Chapter 4. The selected methodology was based on a qualitative approach; accordingly, the research progressed using semi-structured interviews with experts from the construction industry. The semi-structured interview approach was also discussed, and the process of collecting data explained. The credibility of qualitative research and the transferability of its outcomes as essential criteria for quality were addressed. Two sessions of semi-structured interviews were conducted during the research, and the corresponding design of the interview schedule, sampling and population were described in detail. Nvivo 12 was used data analysis, which was found to be useful for deriving themes to add to the robustness of research results.

9.4 Collaboration and Conceptual Framework

According to the research strategy designed in Chapter 4, an exploratory study was undertaken in the first phase of the research, relying on 25 interviews wide spectrum of industry practitioners who were familiar with BIM and worked in BIM-enabled projects across Australia. All of the interviews were semi-structured, allowing respondents to express their opinions and perspectives about collaboration challenges and limitations. During the interviews, respondents identified various variables associated with the core dimensions of collaboration as a prerequisite for collaboration in BIM-enabled project that need to be accounted for in the contract forms. Additionally, education and culture change is also identified as essential if collaboration was to be substantially achieved.

The respondents of the interviews confirmed that socio-organisational, technical, and legal challenges have so far hindered the full implementation of BIM, and therefore serious requirements to create governance framework and controlled communication flow are required.

As a consequence of the findings derived from the exploratory study, a conceptual collaboration framework was developed. The framework determines the relationships and interactions of the dimensions of collaboration required to improve the performance of BIM-enabled projects, and identifies the conceptualization of asset information that need to be collected throughout the planned project run time.

In Chapter 6, the collaboration enablers arising from, and supported by, the exploratory interviews that are required to improve the performance in BIM-enabled projects were then legitimised by rules and judgments concluded in previous legal cases. In order to establish a procedural point, issues of law raised by precedent cases were summarised for onward consideration in conjunction with existing contract forms.

In summary, the outcomes of Chapter 6 provided evidence from a legal perspective that collaboration blockers can be addressed and solution incorporated into the current procurement paths. Accordingly, harmonised combination between legal and contractual arrangements can be achieved to enhance the adoption and diffusion of BIM across industry.

9.5 Framework Validation

BIM is a process that defines how to use 3D-objects for digital information exchange between owners, architects, engineers, contractors, and suppliers. The BIM ideology opens for geometry and information to be reused for more than one purpose, making the design and construction a more efficient process. Diverse disciplines use building information in a unified collaboration, which requires that professions within design and construction understand the needs of each other. Achieving such level of understanding requires optimal collaboration between the relevant project participants.

As a result of the qualitative studies (Chapter 1 to 4), a novel governance-based framework has been developed, which incorporates the socio-organisational, process, and technology dimensions of collaborative work that is required to support BIM. The framework, as assumed and emphasized in Chapter 5, aims to have the project develops in an integrated process based on the cyclic development of design and construction work that involves all parties. Team members and organisations (owner, architect, contractor and supplier) become a collaborative unit, information and techniques are available at the right time, errors and redesigns are discovered at earlier stages, liability is shared and right type of expertise is used to evolve the LOD (level of detail) of the project strategically.

The derived collaboration core dimensions and associated variables and their parametric relations have then examined by precedents from case law, as reported in Chapter 6, and further validated through 15 in-depth semi-structured interviews with industry practitioners. The governance-based collaboration framework provides a much-needed platform to engender collaboration with the prevailing legal environment within which construction projects are procured.

9.6 Recommendations from the Research

The research findings have resulted in a collective of lessons that organisations in the construction industry should address to enhance their collaborative performance and achieve BIM full benefits. These include:

- organisations need to take serious steps to change the culture that promotes adversarial approach into collaborative based culture. Training and upgrading of qualification, communication, and leadership development are best to implement such change.
- stipulate the roles and responsibilities of team members and what is expected to achieve.

- adopt and implement the approach of sharing responsibilities as opposed to relying on a hierarchy of authority.
- organisations should involve BIM-ready teams in BIM-enabled projects. Procurement solely based on competitive cost should not be implemented, quality and readiness to work in a collaborative environment should be considered.
- organisations should provide management support, reliable means of communication, and IT infrastructure to their teams to enhance trust and hence, achievement of the required objectives. Adopting the use of digital documents result in increased accessibility to information, reduced production cost, increased value from information repositories, and knowledge bases.
- organisations should promote collective work and motivate the sharing of knowledge and information between teams. Motivation scheme with promised rewards is required.
- establish networks on personal and professional level to enhance communication flow and sharing of information
- the implementation of scope management and change control scheme to track all changes and record decisions
- incorporate the duty of care and liability for foreseeable damages into the contractual framework and have all teams acknowledged the liability to protect each other
- undertake regular design checks and verifications through collective design review sessions that involve all concerned parties with liability to warn for any spotted omission
- auditing and sign-off procedure of any transmitting document to ensue authentication of information
- identify sensitive information and establish security scheme to protect confidential information not being used by unauthorised parties

Finally, it is recommended that organisations should seriously consider to address collaboration barriers that the proposed conceptual framework suggested if the collaborative performance is to be improved.

9.7 Future Research

This research is the first that sought to identify the collaboration barriers that significantly influence the adoption and implementation of BIM in construction industry, propose a framework of main tenets and associated variables, and used precedent case laws with court judgments to validate the proposed collaboration framework.

Substantial knowledge is now known from a legal perspective about the potential for organisations to enhance their collaboration so they can collectively perform more efficiently and effectively in providing the required level of services. The research provides insights into the existing body of knowledge by providing references to case laws to contractually support the creative nature of collaboration that BIM requires.

The international law differs across boundaries, and therefore similar investigation can be conducted in different countries using the same research methodology that this research implemented and make further references to case laws. It is evident that further research is worthwhile on the following topics:

- how organisations should implement the culture change in the context of the evolving technology and digital engineering
- the integration between change management and legal framework to build on BIM implementation
- BIM full implementation requires amending the existing legal structure to expressly address the various collaboration barriers that this research has identified.

9.8 Chapter Summary

This chapter has drawn together the threads of all previous chapters of this research and explained how socio-organisational, information sharing, digital engineering, and information accessibility concerns are raised quite legitimately as reasons why collaboration in the construction industry is not actively achieved. Discussion has then moved further and focused on the critical elements that influence collaboration, aiming to identify the issues that, if successfully addressed, can facilitate optimal collaboration between team members.

A series of recommendations have been drawn from the research findings, which can be provided for industry practitioners. Recommendation includes: (1) successful collaboration requires a combination of people, processes and technologies; therefore an environment where team members actively share ideas and information freely in a fluid and dynamic fashion is needed; and (2) collaboration need to be built into the organisations' processes and applications to achieve active participation.

It was suggested by the interviews that information sharing acts as the major impediment to the implementation of collaboration. BIM has been acknowledged as an effective and efficient technology and method for accessing and presenting information related to the delivery of construction projects (e.g, design, build, operation and facility management). Furthermore, BIM acts as a catalyst for future proof construction industry and enables the successful management of an asset all the way through the whole life of the project. In summary, BIM not only can provide digital representation of the physical and functional characteristics of an asset, but also can provide key decision-makers with the ability to make informed decisions across a project’s life-cycle. However the implementation of BIM is challenged by the traditional legal structure which remains adversarial, and thus changes to incorporate collaboration into the various procurement methods is needed. This research is significant as it reveals a series of precedent court judgments that enable achieving the incorporation of collaboration and all associated variables into the contracts. Accordingly meeting the initial aim and objectives.

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APPENDICES

Appendix A

Collaborative Framework for BIM-Enabled Construction Projects

Exploratory-Study Protocol - I

Must do:

- ✓ Before the interview commences make sure the *plain language statement* and authorisation from the interviewee are sought. Also as their permission to digitally record the interview. Notify interviewee their interview will be transcribed and distributed to them for vetting/approval.
- ✓ Ask the interviewee to select a recently completed BIM-enabled project or one that they are currently involved with.
- ✓ State that we would like the interviewee to provide assistance in acquiring a deep understanding of challenges associated with the collaboration and suggest what necessity and directions of a new approach to enhance collaboration
- ✓ Before the interviewee provides answers to the questions, however, some background information about the project is first sought.

Ref: Date: Start Time:

Interviewer: Finish Time:

Interviewee: Gender:

Organization: Position:

Organization Type:

Industry Experience:

Before commencing the interview:

- present the interviewer and identify the interviewee
- provide brief overview of the research and the intended objectives. Information that may influence the interviewee's opinion will be avoided
- inform the interviewee that additional questions maybe asked at the end of the interview session

Background Information

1- Description of the project(s) (project type/purpose/procurement method)

___

___

___

2- Project(s) value: $ ___

3- Project(s) duration: ___

Collaboration Practices in Construction Industry

4- Please outline past involvement in BIM enabled projects and your roles and describe how collaboration impacted the project's outcome?

___

___

___

5- Were there tools or contract situations that shaped the collaboration in one way or the other? If yes, please explain

___

___

___

6- Were there any collaboration related issues between other team members? If yes, please provide examples, how were the parties able to resolve the issues?

___

___

___

7- What methods are being used for storing and sharing data between team members? What are the technical challenges associated with such methods (if any)?

___

___

___

8- Were there any data management framework to implement data sharing across project's lifecycle? If yes, please explain the framework structure

___

___

___

Governance Framework

9- What are the key success factors in collaboration?

10- What "in your opinion" is required to create a framework to manage the availability, integrity and security of data that stakeholders use at different stages of building's lifecycle and, their rights to insert, extract, update or modify information?

11- How negotiation and openness to problem-solving process is appreciated and maintained by all participants?

Collaboration Barriers

12- How information and communication technology impact collaboration and BIM adoption?

13- What are "in your opinion" the legal, contractual and technical barriers to collaboration and BIM's implementation?

14- What are the organisational barriers to collaboration and BIM implementation?

15- What are the main technical challenges that preclude seamless exchanging of information between participants?

Resources and Expertise in Collaboration

16- What inter and intra disciplinary problems that evolve during collaboration, and what approach is in place to resolve such problems?

17- How skilled resources are shared between parties, and what motivate them to share resources?

Mutuality

18- How do information flows between parties without dissipation and unintended corruption?

19- How do you assess team members' commitment to internal resolution of conflicts?

20- How to ensure that common-interest is placed above self-interest?

Trust and reciprocity in collaboration

21- What obligation that trust entails to partners?

22- How to accommodate partners that are not willing to trust?

23- What is the role of organization in building and sustaining trust?

Appendix B

Collaborative Framework for BIM-Enabled Construction Projects

Exploratory-Study Protocol - II

Must do:

- ✓ Before the interview commences make sure the *plain language statement* and authorisation from the interviewee are sought. Also as their permission to digitally record the interview. Notify interviewee their interview will be transcribed and distributed to them for vetting/approval.
- ✓ Ask the interviewee to select a recently completed BIM-enabled project or one that they are currently involved with.
- ✓ State that we would like the interviewee to provide assistance in acquiring a deep understanding of challenges associated with the collaboration and suggest what necessity and directions of a new approach to enhance collaboration
- ✓ Before the interviewee provides answers to the questions, however, some background information about the project is first sought.

Ref: Date: Start Time:

Interviewer: Finish Time:

Interviewee: Gender:

Organization: Position:

Organization Type:

Industry Experience:

Before commencing the interview;

- present the interviewer and identify the interviewee
- provide brief overview of the research and the intended objectives. Information that may influence the interviewee's opinion will be avoided
- inform the interviewee that additional questions maybe asked at the end of the interview session

Background Information

1- Description of the project(s) (project type/purpose/procurement method)

2- Project(s) value: $

3- Project(s) duration:

Socio Organisational and People Issues

4- What in your opinion the impact of shared responsibility on collaboration?

5- What in your opinion is the impact of Trust on collaboration?

6- How in your opinion incentives motivate collaboration?

7- How in your opinion education and awareness motivate collaboration?

Information Sharing

8- How in your opinion duty of care impact collaboration?

9- How in your opinion duty to alert impact collaboration?

10- How in your opinion information integrity impact collaboration?

11- How in your opinion information ownership impact collaboration?

12- How in your opinion Professional Negligence impact collaboration?

Digital Engineering

13- How in your opinion admissibility of evidence impact collaboration?

14- How in your opinion data accuracy impact collaboration?

15- How in your opinion Data authentication impact collaboration?

16- How in your opinion unauthorised access to data impact collaboration?

Technology, and Information Accessibility

17- How in your opinion human error and manipulation impact collaboration?

18- How in your opinion competency impact collaboration?

19- How in your opinion intellectual property impact collaboration?

20- How in your opinion liability for misrepresentation impact collaboration?

Appendix C

Appendix C: Coding of the data collected from the exploratory interviews

Collaboration Dimensions and Associated Shortfalls	**Responses of the Interviews (respondents)**	**Respondent's Codes**
	I think that there is an education responsibility here, so we educate young people through universities with new technology, but the knowledge, in the industry, lies in people that have experience. At the minute, there is a big gap between those two, and something like BIM, makes that gap even bigger, because these young people come through with excitement about what it can do, and no knowledge of what can go wrong, and because these two people don't talk to each other, you end up with quite a risky situation. Therefore I think, that there is an education process that needs to go to the strategic level as well, to enable them to be able to foresee and anticipate the gaps and be able to open the door that says (This is the world that these people are living in now and your QA processes don't work with this anymore)	AP-01
Collaboration Main Dimensions	Design meetings on regular fashion enable actors from different engineering disciplines to exchange their technical knowledge about the design itself and to confirm progress update. Regular exchange of information helps to create shared understanding on both aspects, integrate knowledge to expedite work progress, and ultimately achieve the common objectives	GA/PM-01
	Effective communication and clear understanding of professional roles and obligations are the core competencies and fundamental prerequisite for collaboration to occur.	AM-01
	Interprofessional education provides an opportunity to understand other professionals' area of expertise and viewpoints, and thus improve	A-01

professional attitude, knowledge transfer and collaboration skills	
Because we were taught to act as silos, we are adversaries, and we need to move away from that.	A-02
Collaboration efforts towards the selection of sustainable design options are obstructed by the traditional procurement methods	A-03
Information governance as how to share and communicate information between project parties, and the contract arrangements form the main legal challenges that impact collaboration	A-04
In non-adversarial team environment, everyone understands the roles and responsibilities of others. Through regular meetings using open dialogue and risk sharing, an atmosphere of mutual trust is produced and hence facilitate collaboration towards common aim.	MEP-01
Information and communication technology enable the exchange of information across organisational boundaries and hence better understanding among team members t build relationships and develop trust.	MEP-02
My personal authority is limited to the technical aspect, therefore for any commercial decision, higher management approval is a must	SE-01
The contract should always allow for an opportunity to reward the design team based on sufficient and economical design delivery, and not merely based on the percentage of construction cost	SE-02
The level of delegated authority indeed influence the performance and hence collaboration. The main issue in my opinion is that contractors often accept the projects at almost no profit margin, and aiming for variations, which compromise collaboration plans. Therefore contractors' offers need to be reviewed by technically educated decision makers. It is always said that	SE-03

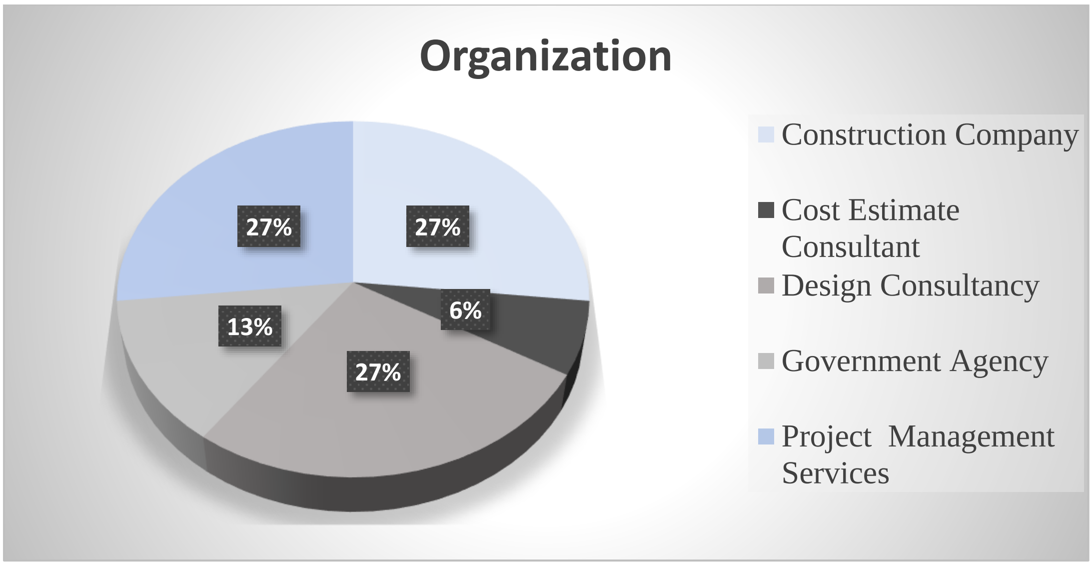
	lowest offer might not be awarded the project however so far I have not seen this condition implemented.	
	My past involvement with BIM was on a large infrastructure project at Perth Airport for the terminal expansion, and BIM was implemented as a variation to the contractor after the execution of the contract (eight weeks after commencement), and it was administered by the contractor with a view to deliver the BIM LOD500 model at the end as part of the handover documents. The cost of this variation was estimated by Catalyst (organisation from South America), which we engaged in providing cost estimate, and we administered the variation through the contract. The contractor didn't really have much choice in accepting the variation. The project is now in dispute and under court review. The contract was signed between the contractor and the client at that time; however, the contractor by then engaged their subcontractors who then had to buy into the BIM ethos and processes. The subcontractors are of all engineering disciplines. Collaboration was very fragmented. The late issue of variation has put parties in the position where they were not across as to what happens in BIM. Parties were not geared up to administer BIM. Although the contractor accepted the variation based on the cost provided by Catalyst, the knock-on effect was in the form of the additional cost that the contractor incurred when approached subcontractors to implement BIM. Collaboration was not solid at all	PM-01
	Placing common interest above personal interest needs to get the parties out of their houses into the overall office. And doing that takes more than just a fee, you've got to create an environment that those parties participate in, to achieve that. So, you take it away from your traditional construction delivery, confrontational approach, to more of a	PM-02

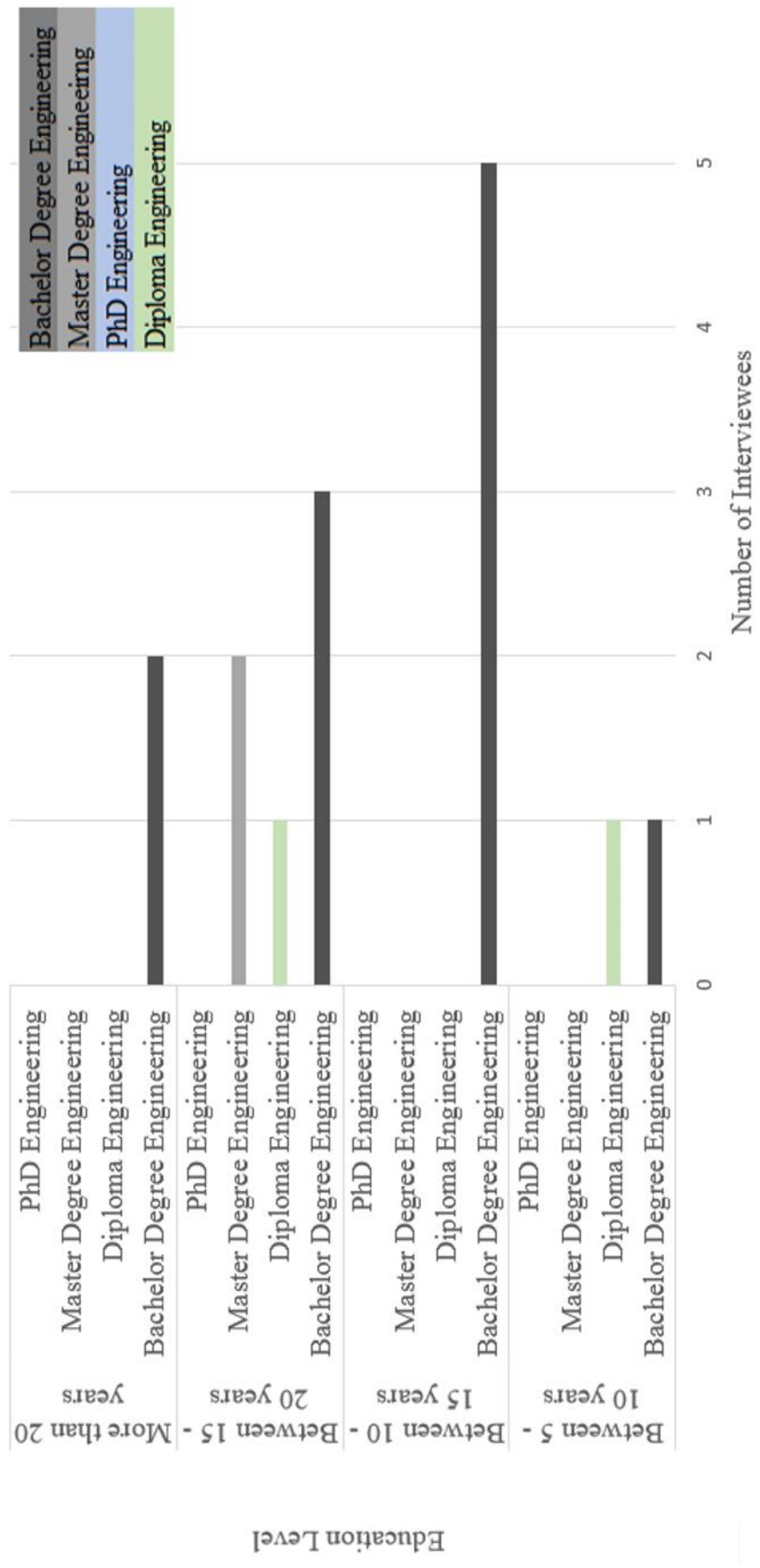
	supportive, integrated, complete approach. It's a tough one to manage, because it's human management, as well as professional management, as well as task management	
	Trust exists in the professional organisations, who see the benefit of keeping in contact with their peers. However, once a contract is executed and construction kicked-off, time to deal with subcontractors starts. Subcontractors are parochial, so they probably open to collaborate and trust other team members if they are making a profit on the project	PM-03
	Organisation role is essential in building trust culture. Even if clauses are mandated, without culture and willingness to perform it won't work. But it depends on the situation as it's a matter of risk assessment. There are defensive companies, and then there are companies that do want to work with you, and learn from each other	PM-04
	Rewards do not necessarily be monetary, but motivation should be in the form of promises to re-contract	QS-01
	Two-stage contract where principal contractor is appointed following the completion of design work is insufficient to ensure team integration and collaborative work. I think uncertainties between design and construction activities are better addressed when both design and construction teams are appointed at the same time.	QS-02
	Trust has not been sensed amongst engineering disciplines because each party is looking after their self-interest. However, culture change is what they called for, and they signed off on "change culture- pave the future"	QS-03
	Loss of data while transferring files from design teams to our systems happens more often which subsequently consume more time to complete the model	C/PM-01

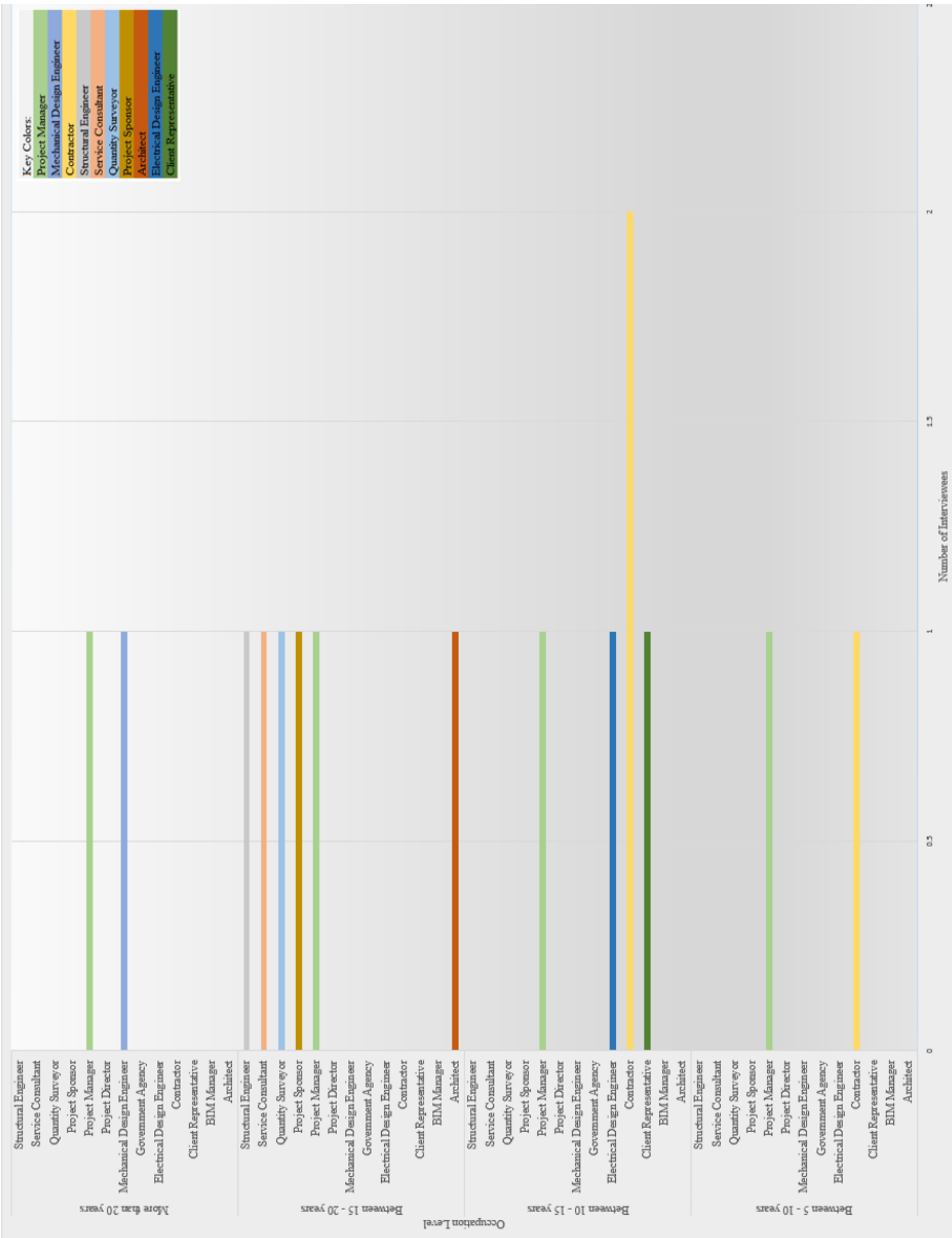
Liability for incomplete or wrong information should be stipulated in the contract	C/PM-02
Due to current procurement practices, we lack the integration between design team members and contractors. This shortfall can be addressed through collaboration	C/PM-03
The contract should have stipulated the BIM requirements, and that variation provision should have been stipulated to include all parties. However, the best method to implement BIM is to involve the designer, contractor and operator to get their buy-in then build the model and then send off the documents for construction. However prior to commence construction we need to tender the design and appoint main contractor with clear BIM requirements, so when the main contractor appoints their subcontractor, every party is aware of BIM requirements before contract award. Such awareness makes it very easy to implement BIM. It is imperative to select all parties correctly to ensure BIM implementation	BM-01
A solution for data storage with access policy is required to facilitate information sharing between team members	BM-02
Reliable data structure and communication practice are essential to enable team members to keep track of information and changes	BM-03

Appendix D

Appendix D: Classification of respondents: demographic information




Bachelor Degree Engineering
Master Degree Engineering
PhD Engineering
Diploma Engineering
More than 20 years
Between 15 - 20 years
Between 10 - 15 years
Between 5 - 10 years
PhD Engineering
Master Degree Engineering
Diploma Engineering
Bachelor Degree Engineering
0
1
2
3
4
5
Number of Interviewees
Education Level


Key Colors:
Project Manager
Mechanical Design Engineer
Contractor
Structural Engineer
Service Consultant
Quantity Surveyor
Project Sponsor
Architect
Electrical Design Engineer
Client Representative
Number of Interviewees
Occupation Level
More than 20 years
Between 15 - 20 years
Between 10 - 15 years
Between 5 - 10 years
Structural Engineer
Service Consultant
Quantity Surveyor
Project Sponsor
Project Manager
Project Director
Mechanical Design Engineer
Government Agency
Electrical Design Engineer
Contractor
Client Representative
BIM Manager
Architect
0
0.5
1
1.5
2

Appendix E

Appendix E: Collaboration components and corresponding control actions

Artefact in focus	Control Mechanism
Governance	
The exchange of information and update between participants	Regular design and risk management meetings
Collaboration motives	Expressed inclusion of consequential damages
	Educational and cultural change that appreciate technology evolution
Contractor’s engagement and risk of unknown	Early appointment of principal contractor along with design team to ensure design intent is comprehended and BIM benefit is appreciated against adequate time/cost compensation
Administration	
Common Interest is put above self-interest	Education and culture of willingness to work together
Scope of work and obligations	Requirements and expectations need to be clearly stipulated.
Autonomy	
Delegated authority	Coordinated and structured decision-making process
Mutuality	
Maintain shared interest	Culture change
	Reward for efficient and cost-effective design
	Common benefits
Trust & Reciprocity	
Trust obligations	Commitments to achieve deadlines
Organisation’s role	Adopt into core values and leadership
Non-compliant member	Preference to replace

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Co-author Attribution Approval Statement

Hereby, I, Dr. Oluwole Olatunji, confirm that the following is my joint publication with Adam Alwash. I, as a co-author, endorse that the level of all authors' contribution is accurately and appropriately addressed in the following table. I also consent this journal paper to be used in the thesis "Development of Collaborative Contractual Framework for Building Information Modelling Enabled Projects", submitted for the Degree of PhD in Civil Engineering of Curtin University.

Journal paper: Adam Alwash, Peter Love, Oluwole Olatunji, "Impact and Remedy of Legal Uncertainties in Building Information Modeling", ASCE- Journal of Legal Affairs and Dispute Resolution in Engineering and Construction. p. 1-7, 2017.

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Authors		Conception and Design	Acquisition of method	Data manipulation	Interpretation & discussion	Paper drafting	Paper revising	Final approval
	Adam	X	X	X	X	X	X	X
	Peter Love		X	X	X	X	X	X
	Oluwole Olatunji			X	X	X	X	X
		I acknowledge that these represent my contribution to the above research output. Signed .... Date ....06 January 2020						

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Authors	Adam Alwash	X	X	X	X	X	X	X
	Peter Love		X	X	X	X	X	X
		I acknowledge that these represent my contribution to the above research output. Signed …………………………… Date ….06 January 2020						
	Oluwole Olatunji			X	X	X	X	X

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January 8, 2020

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