DEVELOPMENT OF AN INFORMATION AND COMMUNICATION TECHNOLOGY WORKS INTERFACE FRAMEWORK FOR LARGE SCALE CONSTRUCTION-BASED PROJECT

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ABSTRACT

This research aims to develop an Information and Communication Technology (ICT) Works Interface Framework for large scale construction-based project in construction industry. Based on KLIA Consultancy Services Sdn Bhd's (KLIACS) experiences in managing several large scale construction projects, interfacing problems related to ICT works have been revealed and discussed. Poor integration and coordination of works between ICT and engineering parties were the most common problem encountered in the construction-based project. The interfacing of ICT works with related engineering works should be clearly defined to ensure that neither gaps nor redundancies occurred among the parties involved. Hence, a study on the interfacing problems between ICT and engineering works is significant. A case study on an on-going construction project managed by the KLIA Consultancy Services Sdn Bhd (KLIACS) was selected to gain an insight into the types of ICT and engineering works which are usually found in construction works. An Action Research approach was applied to explore the interfacing problems to identify the common works interface between ICT and engineering, involving all the related parties and at the same time solve the problems while the project was underway. Interdisciplinary techniques such as Requirements Engineering, Focus Group and Works Interface Coordination were used to solve the interfacing problems in the Action Research cycle. At the end of the research, an ICT Works Interface Framework was successfully developed. The framework has proved to be beneficial to those involved in the interfacing works of the construction project managed by KLIACS. Theoretically, the framework provides a proven model to researchers and academia involved with field management for their curriculum module. Generally, this research provides significant contribution to the construction industry as it serves as a guide for companies or government agencies to manage ICT works involving various parties for their entire construction-based projects.

Keywords: ICT works interface, construction interface, interface framework, project integration-

ABSTRAK

Kajian ini bertujuan untuk membangunkan RangkaKerja AntaraMukaKerja Teknologi Maklumat dan Komunikasi (ICT) untuk projek pembinaan berskala besar dalam industri pembinaan. KLIA Consultancy Services Sdn. Bhd. (KLIACS) berpengalaman dalam menguruskan beberapa projek pembinaan berskala besar. Oleh itu, masalah antaramuka yang berkaitan dengan kerja-kerja ICT telah didedahkan dan dibincangkan. Kelemahan integrasi dan penyelarasan kerja di antara pihak ICT dan kejuruteraan merupakan masalah yang kerap dihadapi dalam projek berasaskan pembinaan. Antaramuka kerja-kerja ICT dengan kerja-kerja kejuruteraan yang berkaitan perlu ditakrifkan dengan jelas bagi memastikan tidak wujudnya jurang atau penindanan kerja di antara pihak-pihak yang terlibat. Oleh itu, satu kajian mengenai masalah antaramuka antara ICT dan kerja-kerja kejuruteraan adalah penting. Satu kajian kes mengenai projek pembinaan yang sedang diuruskan oleh KLIACS telah dipilih untuk mendapatkan gambaran mengenai jenis kerja-kerja ICT dan kejuruteraan yang biasanya terdapat dalam kerja-kerja pembinaan. Pendekatan Penyelidikan Tindakan digunakan untuk meneroka masalah-masalah antaramuka, mengenalpasti antaramuka kerja ICT dan kejuruteraan yang kebiasaannya terdapat dalam projek binaan, membabitkan semua pihak berkaitan yang terlibat dan pada masa yang sama menyelesaikan masalah semasa projek sedang dijalankan. Teknik antara-disiplin seperti Kejuruteraan Keperluan, Kumpulan Fokus dan Penyelarasan AntaraMuka Kerja telah digunakan untuk menyelesaikan masalah-masalah antaramuka dalam kitaran Penyelidikan Tindakan. Pada akhir penyelidikan, sebuah rangka kerja antaramuka ICT telah berjaya dibangunkan. Rangkakerja ini terbukti berjaya memberi manfaat kepada mereka yang terlibat dalam kerja-kerja antaramuka projek pembinaan yang diuruskan oleh KLIACS. Secara teorinya, rangkakerja ini memberikan model yang terbukti berjaya kepada para penyelidik dan ahli akademik yang terlibat dalam pengurusan bidang bagi mengemaskini modul kurikulum mereka. Secaraamnya, kajian ini memberikan sumbangan penting kepada industri pembinaan. Ini kerana kajian ini berfungsi sebagai panduan kepada syarikat dan agensi kerajaan untuk menguruskankerja-kerja ICT yang melibatkan pelbagai pihak dalam keseluruhan projek yang berasaskan pembinaan.

Katakunci: antaramuka pembinaan, rangkakerja antaramuka, antaramuka kerja-kerja ICT, integrasi projek

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Last but not least, a special thanks to my wife, Dr. Norziana Yahya, and family for giving me the time and space to complete the demanding and challenging task of writing this thesis.

… Allah will raise those who have believed among you and those who were given knowledge, by degrees … (Al-Quran, 58:11)

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CHAPTER ONE
INTRODUCTION

1.1 Overview

This thesis describes about the issues, problems and proposed solutions of project interfacing that relates to Information & Communication Technology (ICT) works that involve in construction projects. Based on the researcher's experience as a project management consultant in several construction projects, he has gone through a number of project interfacings leading to his interest in ICT works interfacing. Thus, the researcher has taken an initiative effort to explore how to establish ideas and tools for ICT works interfacing in a construction project.

An Action Research has been adopted to carry out a detailed study on the ICT works involve in a large scale construction-based project. A real-live case study has been selected to pursue the research where the researcher involves directly as an active participant in the construction project. The goal is to develop an ICT works interface framework for construction-based project. The initiative starts with revising the ICT works especially involving interfacing works with other engineering disciplines in the construction project. With this effort, it is hope that it could contribute to new knowledge and practical model to the construction industry and academia.

In this chapter an introduction to the current research is provided. Firstly, the background of the problem at the researcher's workplace is described.

Subsequently, the problem formulation comprising research questions, objectives, scopes, significance, limitations, and operational definition of the research are described respectively.

1.2 Background of the Study

The motivation of the study originates from the workplace area of the researcher i.e. KLIA Consultancy Services Sdn Bhd (KLIACS), a registered consulting company in Malaysia providing Project Management Consultancy services to the government of Malaysia to manage major national infrastructure construction projects: airports, railways, hospitals, schools and colleges, bus terminals, office buildings, etc. KLIACS evolved from the Kuala Lumpur International Airport Berhad's (KLIA Berhad) remarkable accomplishment in project managing the Kuala Lumpur International Airport (KLIA) Project to successful completion. KLIACS is a project consulting company which is committed to providing its client with independent, cost-effective and quality services to safeguard the client's interests. KLIACS believes in maintaining close and responsive bi-directional relationship with the client and between all parties concerned in partnership to achieve all project targets and objectives.

Led by a small but highly dynamic, experienced and professional management team, the KLIACS team comprises of professionals from various disciplines. They include project planners, engineers, cost engineers, airport engineers, architects and landscape architects, ICT and system engineers, document controllers, legal & contract consultants, and finance consultants.

Figure 1.1 depicted organisation chart of KLIA Premier Holdings Sdn Bhd with all its subsidiaries including KLIACS.

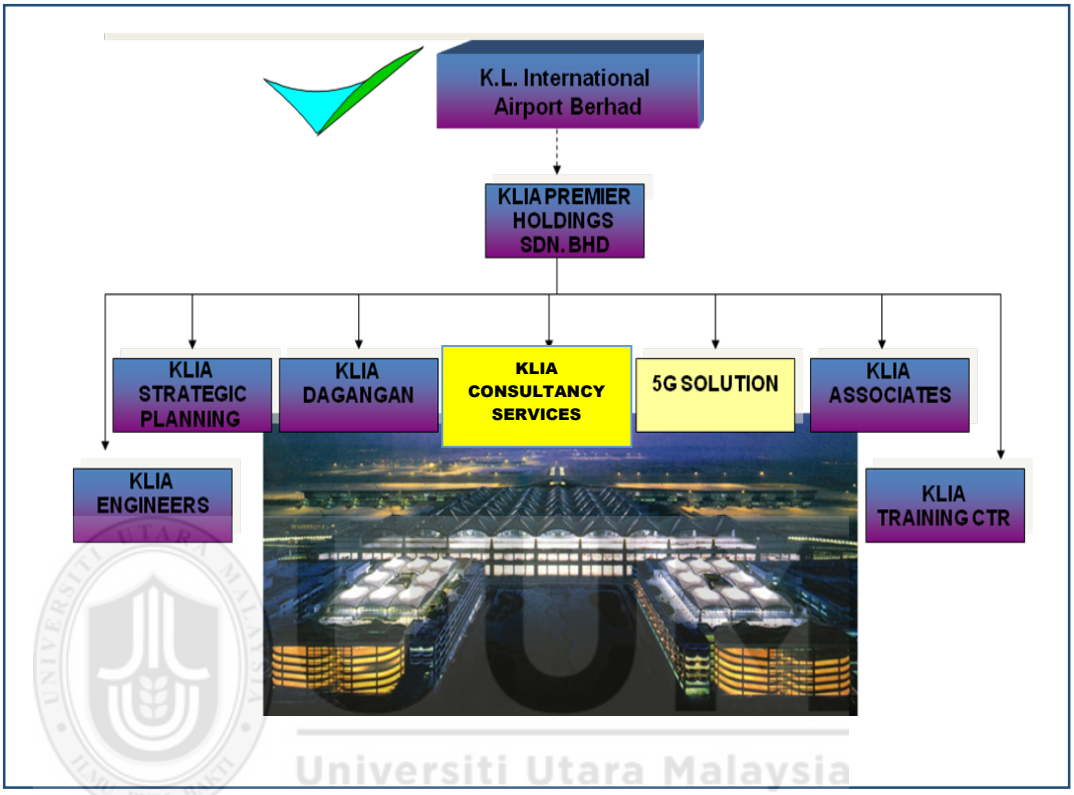

Figure 1.1
Organisation Chart of KLIA Premier Holdings Sdn Bhd. Reprinted from http://kliaholdings.com

Based on KLIACS's experiences in managing several large scale construction projects, the most common problem encountered by ICT consultants and ICT contractors is poor integration and coordination of works between ICT and engineering parties. Every component of works in large scale construction project has its own interface acting as a bridge that allows communication and collaboration process with multi-disciplinary engineering works.

This research seeks to make a contribution to knowledge about construction integration involving ICT works from the perspective of ICT project consultants. To achieve this objective, the research explores how ICT project consultants in a construction project interpret and respond to construction integration. The findings of this research are relevant both to an academic audience, interested in construction integration strategy and management, and to ICT practitioners seeking for revision of interfacing for the ICT works in construction project.

1.3 Problem Statement

Lack of knowledge and little involvement in the construction sector are among the factors that led to the inability of the ICT consultants and ICT contractors to understand the environment of construction works, particularly those involving the work of integration and interfacing. The interfacing processes are not well understood and coordinated properly in those large scale construction projects which have complex tasks of engineering integration. The problems have led to gaps in certain works and overlaps in other works. The gaps have resulted under-bill due to undefined or missing works while overlaps have caused over-bill due to redundancies of works.

Furthermore, the integration framework involving ICT works in construction projects is difficult to obtain or may not exist in the building industry for guidance or reference. Research-related businesses in the management of the interface are more than engineering work and do not involve ICT works as part of integration components. ICT is only used as a tool to assist in managing interfacing works.

This is also a research gap that contributes to the problem statement in this study. Research gaps are discussed further in Chapter 2.

A preliminary study was conducted where the available project documents on the construction projects carried out by KLIACS in the past were reviewed. The main objective of the preliminary study was to prove that there was a genuine issue or problem in ICT works in large scale construction-based project. KLIACS's experiences in managing several mega construction projects involving ICT components revealed that several interfacing problem had occurred between ICT and engineering work. For example, Integrated Transport Terminal – Bandar Tasek Selatan (ITTBTS) was a mega project has experienced problem with ICT works interfaces.

Based on preliminary study which was reviewing on its ICT Project Implementation Plan, (ICT Project Implementation Plan – ITTBTS, 2008) found that the ICT Timeline was not in line with the Master Implementation Plan (MIP). In addition, the ICT Design Document also did not specify the scope of interface that needed to be done during the construction phase (ICT Detailed Design Document – ITTBTS, 2008).There was no ICT works interface framework provided by the construction industry to the project stakeholders, especially the ICT consultants and ICT contractors for their reference. This has further added the problem gaps in the construction integration especially between ICT components and other engineering works.

In conclusion, the preliminary study conducted has the evidence showing the real issue happened in the construction integration involving ICT works interfaces. The importance of interfacing in the integration process makes use of this study to focus on identifying the ICT works issues, interfacing requirements and strategy how to coordinate and integrate with the related engineering works. This will also include the interface requirements development and coordination process of the ICT components and works that make up the ICT Works Interface Framework for large scale construction-based project.

1.4 Research Questions

"How do I improve my practice?" is the underpinning question forming up the action enquiry of this research (Whitehead, 1989). Based on the researcher's involvement and concern in the ICT works in construction-based project, critical questions are addressed with explanations of why this research is engaged.

It starts with the substantive issues in the ICT Works Interface that encourages the researcher to take action. Common interfaces of construction works are observed and processes to be adopted in developing a practical interface framework is explored. The main research question which need to be answered is how to improve ICT works interface in construction-based project systematically and coordinated in order to reduce unnecessary work iterations and delays.

Below are the research questions that have been defined to answer the main research problem:-

1. What are the major issues of ICT works in a large scale construction-based project?
2. What are the common interfaces of engineering works in construction-based project and how the ICT works can be coordinated with them?
3. What are the interface requirements and processes involve ICT Work Interfaces?
4. How to improve the interface between ICT and engineering?

1.5 Research Aims and Objectives

The project aims and objectives are defined and formulated in this section in order to encounter the problems described earlier. The main objective of the research is to develop an ICT Works Interface Framework in construction based project systematically and coordinated. In order to achieve the research aims, the researcher has to explore, discover and gain information of the issues, methods and processes of ICT interfacing practiced during the implementation of the project. Four (4) objectives has been specified to realise the research aims:

1. To explore ICT work interfaces in one of the large-scale construction-based projects currently or recently managed by KLIA Consultancy Services Sdn Bhd.
2. To explore common interfaces of engineering works in the selected construction-based project and to examine the coordination of works between ICT and engineering.

3. To define the interface requirements and processes involve in ICT Work Interfaces.

4. To develop an ICT Works Interface Framework.

1.6 Research Significance

This study is very important as an attempt to address the problems and issues of the ICT work interface and is the first step towards creating an ICT Works Interface Framework for large-scale construction-based projects. The framework is anticipated to serve as practical reference to related stakeholders involved in construction projects as well as theoretical model for academic researchers to conduct further research.

1.7 Scope and Limitations of the Study

Action Research was chosen as the research approach for this study to gain insight and real problem solving experience in a construction project. The Action Research adopted the current KLIACS' project which is Development of Centre of Excellent of Malaysian Rubber Board in Sg. Buloh as the project case study. The project was started in April 2013 and targeted to complete by August 2018.

Due to issues of the land and major changes in the requirements, the project has been delayed for more than three (3) years which led to the longer period of the project implementation and late start of the construction phase. Consequently, the researcher has to limit the scope of his study to the design phase of the project.

1.8 Organisation of the Thesis

This thesis contains six (6) chapters, consisting fundamentally of three parts, as shown in Figure1.1. The following paragraphs describes how this thesis is organised. Chapter 1: Introduction presents the background of the problem, research questions, research objective, research scope, research limitation and research significance. Chapter 2: Literature Review reviews on KLIACS's project management practice and interfacing revision in construction-based project. The link between previous work and the current research on ICT works interface is also discussed.

Chapter 3: Research Methodology presents the approach, methods, techniques in research design for the implementation of the action research. How data is gathered and processes involved in Action Research cycles are described in details. Chapter 4: Fact Findings & Problem Solving describes solutions generated during process of Action Research cycles during the project implementation. Chapter 5: Framework model is built for managing ICT works interfacing with related engineering works. The model is illustrated with the case study conducted at project site.

Chapter 6: Conclusions and Future Research provides a summary of this research. Each solution resulted from each project phase contributing to IWIF development is discussed. The research limitations are pointed out and directions for future research are suggested in the last section.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

In this chapter, framework definition is pointed out so that meaning used is in accordance with the context of operational management which is part of the research subject. Review on previous studies on the framework development is also discussed to know and understand the method used for developing a framework. Interface Management in construction integration is briefed to provide an overview of the challenges and issues of the engineering work interface. Other research efforts on the related works are also explored to seek ideas and example of solutions to the interface problems that have in common.

Next, review of ICT works involved in construction-based project carried out by KLIACS in the past is discussed. Based on the review of other related works and the KLIACS project, a research gap of interfaces between ICT works and engineering works in construction integration is identified and explained.

2.2 Framework Development Review

The literature of construction management is rapidly increasing with frameworks but there has been no attempt in existing literature to highlight the ICT works interface present in existing construction management. This due to the ICT discipline is never been treated as one of the engineering disciplines in construction industries. Therefore, the researcher has taken an initiative to explore

the ICT works interface involve in construction project and developed an ICT Work Interface Framework for construction based project.

Prior to that, the definition of the framework should be emphasized so that its meaning is not excluded from the context of this research. Three definitions of framework have been taken from three sources as stated in Table 2.1.

Table 2.1
Definition of framework

No.	Source	Definition
1.	Longman Dictionary (https://www.ldoceonline.com)	"a framework is a set of ideas, rules, or beliefs from which something is developed, or on which decisions are based"
2.	Collins Dictionary (https://www.collinsdictionary.com)	"a framework is a particular set of rules, ideas, or beliefs which you use in order to deal with problems or to decide what to do"
3.	Business Dictionary (http://www.businessdictionary.com)	"a framework is a broad overview, outline, or skeleton of interlinked items which supports a particular approach to a specific objective, and serves as a guide that can be modified as required by adding or deleting items"

Reviews on previous related studies on frameworks have also been carried out to select the appropriate framework method that could be adopted for the development of the ICT Works Interface Framework. For example, Lindsay Mitchell (2009), has developed a healthcare framework based on lessons from practice. The development of new framework was based on reviewing the use of competence frameworks in the UK's healthcare sector and the exploration of

characteristics of the sector that may influence the success of projects. Since, the method of the development of framework was not based on participative case study, the framework has to be tested in real practice environment to measure the effectiveness of the framework. The disadvantage of this method is that it takes more time to get the results and the results are yet guaranteed.

Deborah Elizabeth Swain (2016), has proposed a knowledge management framework for global project development based on Tai Chi principles and practices. She first proposed a procedural framework or model based on experiential knowledge from practicing Tai Chi while managing project. Tai Chi philosophy was adopted as part of the procedural framework. The objective is for the project teams to reduce stress and improve decision making through exercises, storytelling, and martial arts practices.

Case studies were carried out to get the outcome of the model or framework proposed. The data collected was based on observational case studies during project development. The achievement of the objective presented was based on views rather than measurement on the processes involved. The result was based solely on experts' judgement which is very subjective. It shows that the development of the framework was not based on the construction of work processes and procedures practised but based on the application of martial arts' philosophical into the work culture.

Fiona McAlinden (2015) used Action Research to develop a comprehensive set of policy and procedure documents for Monash Healthcare. The objective was

to develop a strategic response to violence and abuse for all patients of Monash Healthcare especially older people in order to comply with the Government's Elder Abuse Strategy (2009).The research project emphasised on the participatory action research, cooperative inquiry and action learning.

The study found that Monash Healthcare's staffs did not have adequate education, information and resources to consistently identify and respond to situations of elder abuse. Some existing internal Monash Healthcare documents also did not meet the expectations of the State Government, especially responding to abuse of the older people in a consistent manner.

Weaknesses or problems encountered during the research period have been gradually improved until the completion of the proven policy procedures document solving the problem faced by Monash Healthcare. Even though the study was not related to construction industry but the process of producing a set of procedure is very similar with a framework development and it is very suitable for use in Action Research carried out by the researcher (author).

Table 2.2 summarises the critical literature review on the framework development approaches undertaken by other researchers as discussed. It shows the basic comparison and overall understanding of the framework development approach for research that requires framework as part of research deliverables.

Table 2.2

Summary of Critical review on framework development done by other researchers

Research Source	Framework Development Method	Critical Review
Lindsay Mitchell, George Boak, (2009)	Healthcare framework based on lessons from practice. Reviewing the use of existing frameworks. Exploration of characteristics of the healthcare sector that may influence the success of projects.	The framework is not based on participative case study. The framework need to be tested in real practice environment to measure its effectiveness. The framework is not proven.
Deborah Elizabeth Swain, James Earl Lightfoot, (2016)	Procedural framework based on experiential knowledge from practicing Tai Chi while managing project. Case studies were carried out to get the outcome of the framework proposed. The data collected was based on observational case studies.	The achievement is based on views rather than the processes involved. The result is based solely on experts' judgement which is very subjective. The development of the framework was based on the application of martial arts' philosophical and not from the project practice.
Fiona McAlinden, (2015)	The development of framework was based on participatory action research, cooperative inquiry and action learning. Gradually improve the existing procedures based on the problems encountered until success.	The framework is based on the work practise. This framework does not require testing because improvements have been made to achieve the objectives during the research.

In conclusion, the Action research that emphasises on the participatory action research is consider the most suitable approach for ICT works interface framework development. Action Research's cycle which was the essential part of framework development process is discussed in Chapter 3.

2.3 Interface Management in Construction Integration

Project Management Body of Knowledge (PMBOK) has achieved wide acceptance as standard for the conduct of project management. It recognises Interface Management as playing a part in the successful management of projects. However, Interface Management still requires greater consideration than indicated by PMBOK.

Interface Management is much related with Project Communications Management and Project Integration Management which are outlined in the PMBOK. In project management, communications management must address the following questions:

- What information needs to flow in and out of the project?
- Who needs what information?
- When is the information needed?
- What is the format of the information?
- Who will be responsible for transmitting and providing the information?

Whilst integration management is more emphasising on processes of coordinating various elements involved in a project which is comprised of Project Plan Development, Project Plan Execution, and Integrated Change Control. In

integration management, all plans from various parties involved are integrated and coordinated to produce a consistent and coherent document which is used as reference throughout the project. The project manager will execute the project plan according to the strategy and carry out the activities as per the plan. During the project implementation, any changes will be coordinated across the project. Some research indicate that quite significantly a project without practicing Interface Management can contribute up to 20 percent increase of the project cost (Chen, 2007).

Interface Management is not a new concept. The construction industry is also acknowledge that Interface Management processes are critical and the tools that are available to manage those processes are not necessarily tailored or reached in terms of features to accommodate all the aspects that need to be addressed for interfaces. A lot of organizations in the market have been spending time on how to effectively manage the Interface Management (Chen, 2007). They do not really address the aspects of collaboration and the fact that the information ends up being the most important as opposed to some itemized interface in a data plan.

Getting the parties together and having a team environment where they can come together and do collaboration can make a lot of information exchange happen. A very important aspect is making sure all the roles and responsibilities are clarified. Everybody is abiding and applying those roles and responsibilities throughout the process. It is really important to make sure Interface Management is part of overall project information control strategy. Identifying interfaces to all

correspondence such as design drawings, emails, meetings and phone calls become important things in the interface. Everything should be managed in single place so that people can draw relationships between a particular interface and a set of contract or a set of documents that pertain to the interface is vital. Any changes to the project design that affect the interfaces should be traceable and coordinated.

Large scale construction project is an integrated business activity comprising a great number of professional participants, very complex, and it typically covers long-term (Hu and Chu, 2009). As the project grows in scope and complex, there is an increased demand for better cost efficiencies and strict compliance with quality requirements as well as adherence to timeline in engineering construction. As such, construction integration and interfaces are becoming essential matter in construction project bringing a number of key project management challengers including coordination of stakeholders, planning, logistics and Interface Management.

Integrated Transport Terminal - Bandar Tasek Selatan (ITT-BTS), one of the large-scale construction projects carried out by KLIACS is a good example of project case study where the researcher has revealed problems associated with the ICT works interfacing in the construction integration. The development of the ITT-BTS is the culminations of 3 railway stations, bus/taxi station and public parking facilities, park & ride; and commercial spaces.

The overall site development of ITT-BTS encompasses areas of approximately 52 acres which comprised of the following components:-

1) Highway Access Link Bridges and Ramps
2) Highway Access Link and Trumpet Interchange
3) Bus Terminal Area Roads and Ramps
4) Internal Roads Circulation
5) Bus Holding Area
6) Long Term Car Park and Park & Ride
7) Terminal Building
8) Pedestrian crossing bridge
9) Elevated and at grade pedestrian bridges networks from the remote LTCP to the Central Terminal areas.

The project was started in the third Quarter (Q3) of 2007 and completed in the second Quarter (Q2) of 2010, and the building is now known as Terminal Bersepadu Selatan or TBS in short. In addition, the researcher had also involved in the ITT-BTS project as the ICT Manager for three (3) years from project inception till handover. This has made the project review shorter and easier due to the researcher's experience which is much relevant to this research. The TBS provides highly automated bus terminal as the latest technology showcase bringing comfortable travelling by Public Transport (bus service) for public needs. This was made possible by the integration of ICT components and services.

All major events in the terminal are centrally managed from a centre called Terminal Management Centre (TMC). The ICT works involved in the ITT-BTS comprised of the followings major components:

1) Network System
2) Terminal Operating System (TOS)
3) Passenger Information Display System (PIDS) or Digital Signage
4) CCTV System (CCTV)
5) Access Control System
6) Data Centre

All major components involved were building construction related except TOS which was a software-based application supporting the operation of the TMC. TOS was not considered as building construction components because it was a software development effort which did not have any dependencies on the building construction works during the implementation of the project. Therefore, the scope of works of TOS for interfacing with the building related components was not required.

Figure 2.1 depicted a theoretical gap of Works Interface between ICT and Engineering parties which has been compiled and revealed by the researcher based on the project document review and preliminary study on the ITT-BTS project. It shows that two (2) sets of works i.e. ICT and Engineering are grouped with no interface defined. The preliminary study also revealed that there was no interfacing works between ICT and other engineering disciplines being defined in the ICT

Detailed Design Documents. Detailed description of the diagram will be further discussed in Chapter 2.

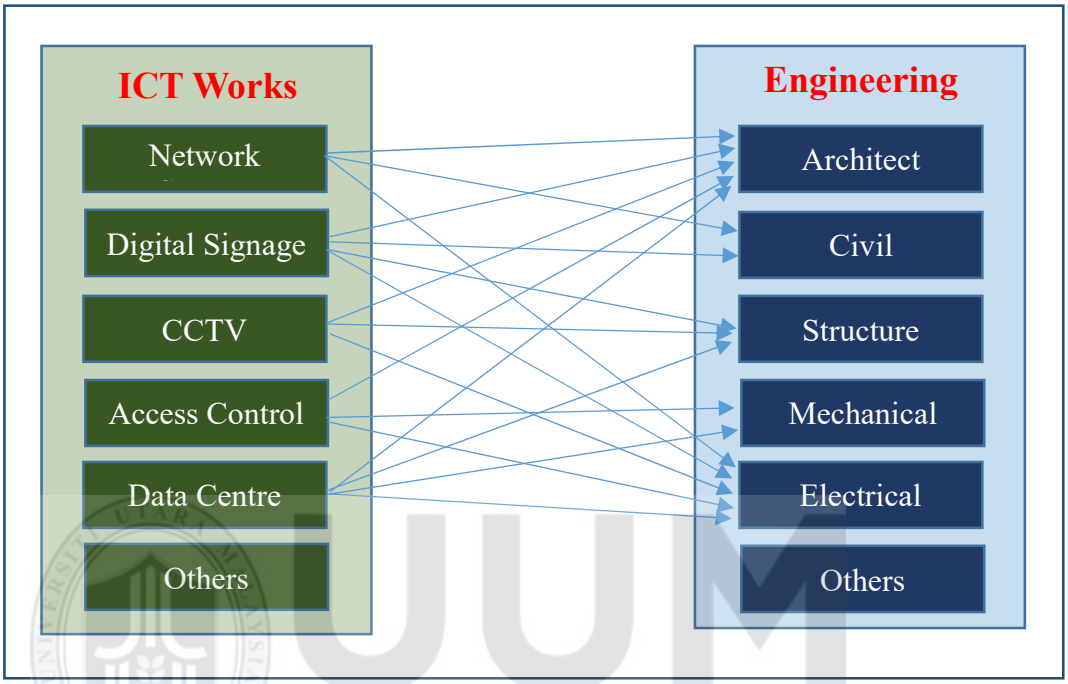

Figure 2.1
Theoritical Gap of Works Interface between ICT and Engineering parties in construction project. Compiled from the Design Document of ITT-BTS project (ITT-BTS, 2008).

The preliminary study found that, one of the major issues in delivery of the ICT works in ITT-BTS project was the unavailability of ICT works interface framework as a guide and reference for the ICT consultants, contractors and system integrators. This has led to inefficiency in term of coordination with related engineering works involved in the construction project. In order to have an understanding of ICT works interfaces which helps towards a systematic and revision of ICT works delivery in construction-based project, a detailed study must be carried out to tackle this problem.

An ICT works interface framework shall be developed to be part of construction's interface process, hence, all or most of the construction projects would be able to coordinate ICT works with multi-disciplinary engineering works. This can also contribute to the enhancement of the interfacing management of the construction project. The study shall explore and identify what most type of ICT works are involved in large scale construction projects. The experiences, resolutions, knowledge and ideas applied during the project implementation shall be collected and recorded, so that, a practical methodology to carry out interfacing tasks with engineering works can be developed and works interface framework can be established.

2.4 Other Research Efforts

The most important aspect of integration is the interface. It is the key factor that allows the integration process or communication occurs. It is also the key area where policies, rules, conditions are being set (Larsson, 2007), coordinated and mapped to permit the activities or works within the integrated components. An interface is a set of defined operations provided and agreed between two integrated works or components (Workflow Management Coalition (WfMC), 2012). Interfacing as defined by Shen, is the key process and the most important entity of construction integration (Shen et al., 2010).

Qian Chen strongly emphasised that Interface Management which is a major part of the integration is very crucial to the success of multidisciplinary construction projects (Chen, 2007).David described Interface Management as

coordinated efforts between work divisions in the project. He also stressed that clarification of works responsibilities is the key for removing the grey area of interfaces (David et al., 2006). The interfaces must be clearly defined and changes to the interfaces must be controlled (Larsson, 2007).

Other studies also showed that lack of knowledge and experience in interfacing and coordinating with multidisciplinary engineering works in construction environment were among the factors contributing to the issue or problem such as incomplete designs, change orders, delays of work, refit, rework, and conflict amongst subcontractors (Luis and Daniel,1998; Nasrun et al., 2014; Shehu and Akintoye, 2010).

Several reports led by industry (Latham, 1994; Egan, 1998; Bourn, 2001; Egan, 2002; Strategic Forum for Construction, 2003) had all asked the industry to change from its traditional modus operandi and do better through increased integration. Reports such as the Egan (2002) and UKCG (2009), had challenged the construction industry to build a fully integrated service that capable of rendering predictable results to clients through processes and project team integration.

Interfacing is the most important aspect and the key process of project integration. It is not focusing on physical interfaces only but it is also involving coordination the project timeline, technical and geographical coordination of engineering works, and communication among different discipline of consultants and sub-contractors (Chen et al., 2007; Siao and Lin, 2012). Furthermore, effective

interface information sharing enables project team members and stakeholders to recognise existing interfaces and solve interface issues and problems (Siao and Lin, 2012).

According to Alarcon and Mardones (1998), improving the design-construction interface is needed in order to achieve integration, improvement in communication and relationships in a project. Despite the numerous discussions and studies in practical literature and academic, there are several case studies to explore real-world problem and solutions for interfacing management during the design and construction phase especially that relate to ICT works.

After reviewing the characteristics of construction and the frequent interface issues, it can be concluded that the Interface Management is the boundary management of project entities (resources, processes, people, schedules, costs, contracts, functions, and risks) to allow a well-coordinated and dynamic construction system.

2.5 Research Gaps

There are quite number of efforts in the Interface Management in construction to support project integration. However, it is very difficult to find any effort focusing on the ICT works as one of the engineering disciplines or components in construction-based project.

Interface Management in the construction industry usually discuss on the interfacing among multi-discipline works that relate to engineering works only. It

is difficult to find studies about ICT works being carried out as part of construction components which involve multi-discipline of engineering works. Most of the studies found that ICT is used as a tool to support the process of the Interface Management.

For example, Fu-Cih Siao and Yu-Cheng Lin (2010) proposed Construction Interface Management System (CIMS) utilising Construction Interface Matrix (CIM) approach to represent the interface information for project team members and stakeholders. The CIMS utilised web technology to improve the Interface Management for project team members and stakeholders to manage interfacing works during construction phase.

Other researchers such as David and Myriam (2006) used Work Breakdown Structure (WBS) matrix to improve interface management in projects. Yu-Cheng Lin (2009), introduced Construction Network-Based Interface Management System. Later he enhanced the efficiency tracking and interface information sharing in construction projects using BIM approach (Siao and Lin, 2012).

In ICT context, the Interface Management includes the activities of defining, controlling, and communicating the required information in order to allow unrelated systems to co-function. Most services or new systems require external interfaces with other services or systems. These interfaces should be defined and controlled in a way that allow the use and change management of these systems or services efficiently. The practice of Interface Management should begin at design and carry on through operations and maintenance.

Typically, ICT work is associated with software development or implementation of a network system to premises in a particular area. ICT development is rarely done in conjunction with building construction except data cabling work which is always associated with electrical works building. This is because the ICT devices are delivered only after the construction of the building complete.

The ICT components have been categorised as operations rather than construction. However, technological developments in ICT has enabled computing hardware integrated with Mechanical & Electrical equipment. This has made some Mechanical & Electrical services have been categorized as part of the ICT trade.

In the past, works such as security system and building automation system were absolutely included in the scope of work of Mechanical & Electrical. As time goes by, technological development in ICT has provided many improvements in data communication in which the status of the equipment and information of Mechanical & Electrical services can be sent or delivered rapidly.

All the services can now be connected to the internet and real-time information for decision-making and action can be obtained anywhere and at any time. For example, the security system can now be accessed by users via the internet. When the system's sensor detects intrusion, the warning signal will be sent to the control panel. The control panel will respond by sending a signal to the siren. The siren alarms and at the same time the control panel will send SMS and make calls to the numbers that have been assigned in the system's control panel.

Users receiving the alert able to access the system's website and see what is happening via CCTV cameras online.

Another example, Building Automation System (BAS) is a microprocessor-based control and computer system. It centralizes the monitoring, operation and management of buildings to achieve a more efficient operation and implementation of strategies for energy management. BAS is an important component in the control facility and building's energy management system for creating an Intelligent Building.

The scope of control of the BAS is large which involves handling regulation and the implementation of BAS for computerized against Air Handling Units (AHU), which is one of the equipment of heating, ventilation and air conditioning (HVAC). This is in line with the 'intelligent building'. Intelligent building concept is an alternative choice to overcome the energy crisis or the energy in the early 1970s, when developers were forced to control and monitor energy consumption using a centralised system.

As of this thesis report is written, no written study about the work of the ICT in the construction sector is found. What was found is a number of studies on ICT tools such as the use of Building Information Model (BIM) for construction Interface Management.

2.6 Chapter Summary

In summary, the literature review has identified several gaps in the scope of the existing research on the ICT Works in construction-based project which are:

a) Most studies focus only on the engineering related works, but few or none focus on the ICT works;
b) Practical approach that can be used as reference or guidance for ICT Consultants and Contractors has yet to be established;
c) Systematic framework for ICT Consultants and Contractors need to be developed.

Therefore, it can be asserted that the revision of ICT Works in construction project requires an analysis of the interfacing works between ICT and engineering parties. A systematic framework, which consists of a detailed process and a practical approach can contribute to the body of construction integration knowledge in the project management.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research methodology used to achieve the research goals and objectives as defined in previous chapter. First, the chapter starts with the research framework that explains the research processes involving activities and phases. Secondly, the research design is described and justification of the research method adopted is clarified. Thirdly, approach of data collection involving focus group, document reviews and observation of activities are presented. Lastly, data analysis procedure is described.

3.2 Research Process

Research process is the structure that outlines the activities planned to conduct this research. It was conducted in two (2) phases as depicted in *Figure 3.1*. Phase 1 covers the activities carried out during pre-research action which comprises of the followings:

a) Problem Statement
b) Problem Formulation
c) Literature Review
d) Research Design.

Whilst Phase 2 covers the activities carried out during research action which comprises of the followings:

a) Life Case Study
b) Problem Analysis & Solution Development
c) Problem Solving
d) Framework Development
e) Thesis Completion

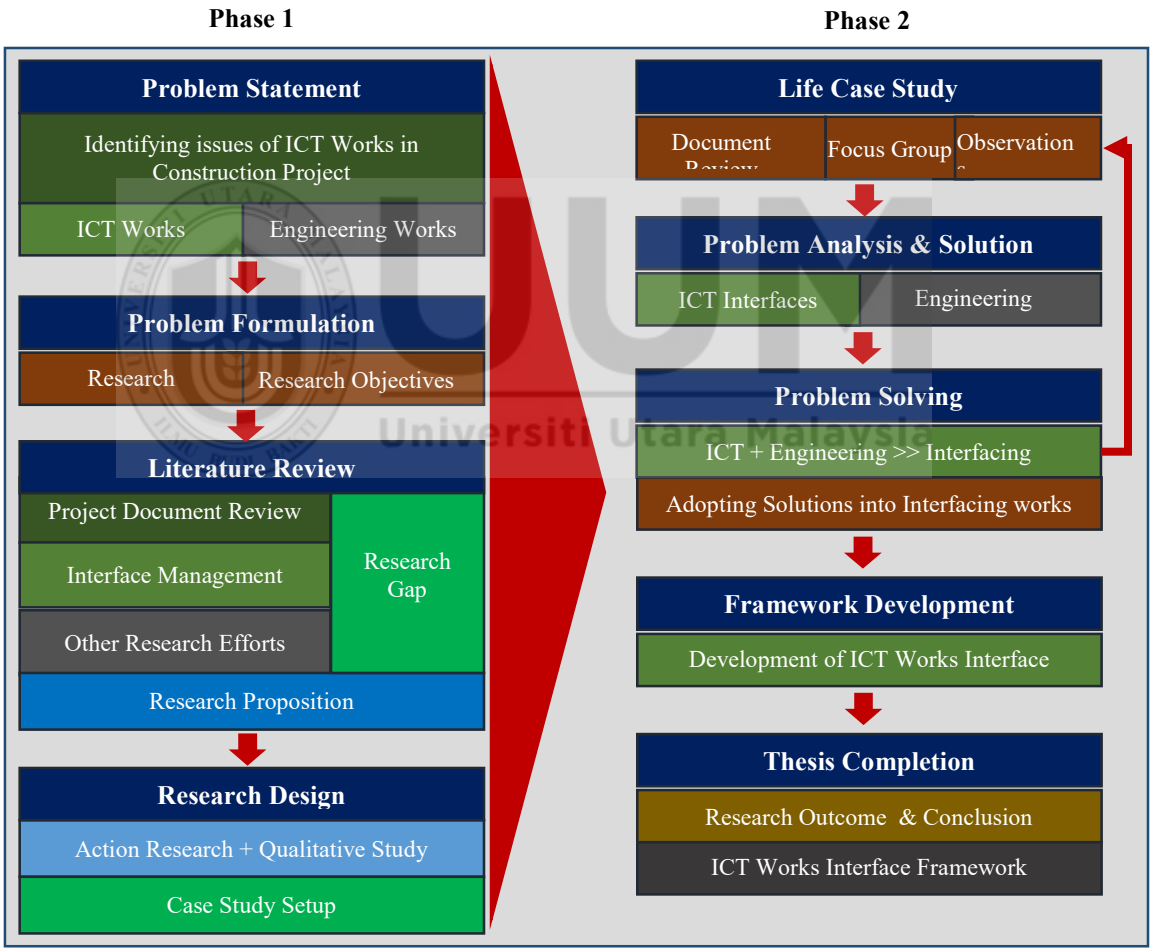

Figure 3.1
Research Process Flow

Phase 1 is the pre-action activities before research in action begins. It starts with the problem statement highlighted by the researcher who already has problem at his work place i.e. KLIACS. The researcher's experiences in managing ICT works in construction projects in the past are also taken into account to establish the problem statement.

A preliminary study was conducted where the available project documents on the construction projects carried out by KLIACS in the past were reviewed. As stated in the Section 1.3, all the problems and essential issues that related to ICT works interface were used to form up the problem statement of the research. Literature on the theories and practices which have similar area and subject is presented in Chapter 2.

Based on the result of the literature review, a research proposition was formed as the foundation for the research design. An Action Research process for the development of ICT Works Interface Framework was set up. Action Research was selected because it is the most appropriate research method that can fulfils the researcher's needs which is to solve the problem at his workplace during working. Qualitative case study research has been used in data collection method which involve focus group, document review and observations.

Phase 2 begins after the research instrument for Action Research is completed and ready. A life case study i.e. the construction project where the researcher is currently involved was selected for the Action Research. Related personals and parties to be part as research team were identified and selected. A

framework was developed during the execution of the action research in the construction project implemented.

Any problem related to issue encountered would be discussed and analysed together with the research team. Solution to the problem was then constructed and applied to the project operations. This process was repeated as cycle until the problem is solved. Project operations are considered to have been completed if problems or issues have been resolved. Otherwise the process would not move to next stage. Solutions that contribute to solving the problem was then selected to be part of the structural framework. At the end of the project operations, all the problems encountered were already solved and the framework was established.

Table 3.1 summarises the research tasks and deliverables. It shows the overall mapping starting from the research questions till research deliverables. For example, research question no. 2,"What are the common interfaces of engineering works in construction-based project and how the ICT works can be coordinated with them?", is mapped with the research objective, "To examine interface requirements and coordination processes for ICT works and engineering works". Specific tasks i.e. project document review, observation on the project activities, discussion with the focus group, and interviews with multi-discipline engineers have were then be exercised to achieve the research objective mentioned earlier. The outcome from these activities was the ICT Interface Requirements which was part of the deliverables.

Table 3.1

Tasks & Deliverables

No	Research Question	Objective	Activity(s)	Deliverable(s)
1.	What are the major issues of ICT works in a large scale construction-based project?	To explore and discover type of ICT work interfaces in one of the mega projects currently or recently implemented in Malaysia.	Project document review. Observation on the project activities. Discussion with Focus Group. Interviews with multi-discipline engineers.	Problem formulation
2.	What are the common interfaces of engineering works in construction-based project and how the ICT works can be coordinated with them?	To examine interface requirements and coordination processes for ICT works and engineering works.	Project document review. Observation on the project activities. Discussion with Focus Group. Interviews with multi-discipline engineers.	ICT Work Interface Requirements
3.	What are the interface requirements and processes to be defined for the development of the ICT Works Interface Framework?	To define the interface requirements and processes involve in ICT Work Interfaces	Project document review. Observation on the project activities. Discussion with Focus Group. Interviews with multi-discipline engineers.	ICT Work Interface Control.
4.	How to develop the ICT Works Interface Framework?	To develop interface framework that includes models and methodology for delivering ICT works interface in construction-based project.	Project document review. Observation on the project activities. Discussion with Focus Group. Interviews with multi-discipline engineers.	A set of ICT Work Interface Framework.

Table 3.2
Operational Framework

Stage	Duration	Tasks
Stage 1 **Understanding Research Background and Preliminary Study:** Identification of issues based on past experience and projects. Past Project Analysis.	6 months	Document review; and past observations/experiences Explore and understand the issues of ICT works in construction project. Review project documents and related journals. Problem formulation and research plan.
Stage 2 **Literature Review:** Construction Interfaces & Research Design	6 months	Literature review – Engineering works interface Identification and Selection of Project Case Studies.
Stage3 **Project Case Studies:** Participant Observation, Information Gathering & Analysis. ICT Works Interface Framework (ICTWIF) Development	18 months	Practical application in current project. Data collection – document review; interviews of focus group, and observations/ Problem definition & solution generation.
Stage4 **Result Analysis & Conclusion:** (Thesis Completion)	6 months	Research outcome analysis. ICTWIF revision and final draft Conclusion and completion of the thesis.

Table 3.2 describes the operational framework of the proposed research to achieve the main objective of the research. This research was mainly focusing on the interface architecture of an ICT work package and its interrelation among the multi-discipline engineering works as to provide interoperable in construction integration. It also sets out interfaces planning and how the integrated works are expected to be carried out.

3.3 Propositions Development

3.3.1 Overview

This research was initiated by the researcher who already has work experience in managing ICT works in construction projects carried out by KLIACS, a company in which researcher is working. Based on the project documentation review and researcher's experience in managing ICT works in ITT-BTS project as described in section 1.3, the main research proposition is:

"the development of an ICT Works Interface Framework, which comprises a detailed process and practical approach that can contribute to the revision of construction integration success between ICT and other engineering disciplines in a large scale construction-based project."

Three (3) major gaps were identified in the preliminary study which is described in section 2.5. To overcome these gaps, a study on the interfacing process is required in order to understand the real problem happened and gain insight of the operations involved in the construction project. An appropriate research type and method needs to be reviewed, selected and established.

3.3.2 Identification and Selection of Research Type

The first step in conducting research is to determine the most fit research design to use. Approach and method of a research is mainly

determined by the problem being studied. Two (2) type of research i.e. Qualitative Research and Quantitative Research are reviewed and discussed in the following paragraphs.

Qualitative Research is primarily exploratory research. Researchers usually use it to get an understanding of underlying reasons, opinions, and motivations. Qualitative Research gives a view of the issue or problem and helps development of ideas as well as provides hypotheses for quantitative research. Researchers also use it to reveal trends in views and thought, and get deeper into the issue or problem. Methods of qualitative data collection differ by unstructured or semi-structured techniques. Typical methods used are observations, focus groups, document reviews, and interviews. Usually, respondents in small size samples are chosen to fulfil the quota given.

Quantitative Research is mainly used to measure or quantify problems by producing numerical data which the data is then transformed into informative and useable statistics. Usually, it is used to quantify opinions, behaviours, attitudes, defined variables, and generalise outcomes from a bigger sample population. Methods of Quantitative data collection are much more structured than methods of Qualitative data collection. The measurable data is used to generate facts and reveal patterns in research.

Methods of Quantitative data collection include numerous forms of surveys such as online surveys, mobile surveys, paper surveys, and kiosk surveys. Another part of surveys are telephone interviews, face-to-face

interviews, website interceptors, longitudinal studies, and systematic observations.

In this research context, the main goal of the research was to identify and resolve problems that occurred at the researcher's workplace. The researcher involved in making critical analyses of the situations in which he worked starting with small cycles of developing context and purpose, constructing issues, planning action, taking action and evaluating action which helped the researcher to define issues, ideas and assumptions more clearly.

The researcher underwent the cyclic processes and it was repeatedly until the problem is solved prior to enter the next phase. Ultimately, at the end of the phase, an ICT Work Interface Framework was produced based on the successful and proven solution. The approach taken was to revising works by altering it and learning from the consequences of changes. It was participatory because the research was through researcher's work towards the revision of his own practices.

The research developed through self-reflective spiral which covered cycles of planning, action, observation and reflection in all phases of the research process. It began with exploratory change, observation of what happens, collection of data, analysis of data, evaluation of action and then build more refined plans for action.

The research was collaborative because it involved all those responsible for an action, broadening the collaborating group from those directly involved to those affected by the practices concerned. The researcher involved in theorising about his practice which came to understand the relations between actions, circumstances and consequences in his work environment. The theory was rationales for the practice. The research was open ended which was not only keeping records that describe what was happening as accurately as possible, but also collecting and analysing the researcher's judgments, impressions, and reactions on what was going on.

Based on the nature of researcher's problem explained in Chapter 1 and features of research method described, it was clearly shown that the qualitative research method fitted this research needs. Thus, several definitions and types of Qualitative Research were reviewed to gain better understanding on the concept and components of Qualitative Research.

3.3.3 Type of Qualitative Research

Neuman (1997) defines Qualitative Research as "the systematic analysis of socially meaningful action through the direct detailed observation of people in natural settings in order to arrive at understandings and interpretations of how people create and maintain their social worlds".

Qualitative Research is about exploring problems or issues, observing and understanding phenomena, and answering questions by analysing

unstructured data gathered. It involves process of induction until conclusions reached. Based on the literature review, several types of Qualitative Research design were found and categorised as follows:

1) Action Research

Action Research is a site-based research (Thomas and Quant, 1999). The purpose of action research is recommendation for the betterment where researcher involves or participates actively in the real life or natural setting (Silverman, 2010). Data collection will be through participant observation in the whole spectrum.

2) Case Study

A case study is an approach to research that involves in depth analysis of a particular entity or event at a specific time. It comprises of guided interviews with determined focus group, observations and documents review (Yin, 2014). Its focus on a specific case and not characterized by the methods used to collect and analyse data (Carla, 2008). The analysis is more interpretive and the research result is descriptive and narrative.

3) Interpretive

The aim of the design is to understand a situation and make meaning of phenomenon involved. Researcher involve as instrument doing data

collection in the form of interviews, observations and document analysis. Common themes are identified through induction process.

4) Ethnography

Ethnography is about study of cultures, workplace environment and values of people and relationships among them. The result is descriptive of real observation and interviews as well as artefacts.

5) Phenomenology

Phenomenology is about study of phenomena or event where experiences of participants and understanding their opinions. It involves interactive process in data collection via informative conversations and interviews. It also engage with intellectual where analysis on data or information shall be open, tentative, intuitive and meaningful.

6) Grounded Theory

The aim of Grounded Theory is development of new theory. It departs from the ground where data collected will be used for generation of the theory (Barney and Anselm, 2009). It involves a constant comparative analysis and methodological framework where recognition of new ideas and themes are the expected outcome.

Case study is “an empirical inquiry that investigates contemporary phenomena in a real-life context” (Yin, 2014). This approach was chosen due to the researcher’s background as ICT project manager involved in managing ICT works in construction projects, past and current. Flyvbjerg (2006) believed that, in terms of case studies contributions, social science would be strengthened by greater numbers of good case studies. He, however, cautioned researchers to be aware of the misunderstanding of research case studies. He highlighted five (5) biggest misunderstanding of research case studies:

a) practical knowledge is less valuable than theoretical knowledge;
b) one cannot generalise from a single case; as such, scientific development cannot be contributed by single-case study;
c) case study is most useful for generating hypothesis, while other methods are more suitable for theory development and hypothesis testing;
d) verification of case study contains bias; and
e) specific case study is difficult to summarise.

Action research has been designed to attempt to solve problems or issues as well as to revise professional practices in the researcher’s own workplace. It involved data collection and observations which then be used in reflection, evaluation, decision making and the development of more effective ICT interfacing strategies and actions (Parsons and Brown, 2002).

Action research is a natural part of changing practices to revise work environment. It provides a framework that guides practitioners toward a better understanding of what, why, when, and how practitioners become better workers. The term Action research was coined by Kurt Lewin who described Action research as "a comparative research on the conditions and effects of various forms of social action and research leading to social action" that uses "a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action" (Lewin, 1997).

According to Werner and Peter (2004), Action research is "empathy and listening while meeting the other, it is a commitment to basic values like human creativity and democratic participation, it is based on the perception of social reality as a continuing process with individuals being subjects of their history and the social contexts they are dependent on". Peter Reason and Hilary Bradbury (2008) defined Action research as "a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities.".

Shani and Pasmore (2010) defined Action research as "an emergent inquiry process in which applied behavioural science knowledge is integrated with existing organizational knowledge and applied to solve real organizational problems. It is simultaneously concerned with bringing about change in organizations, in developing self-help competencies in organizational members and adding to scientific knowledge. Finally, it is an evolving process that is undertaken in a spirit of collaboration and co-inquiry."

Based on the definitions mentioned above, the researcher can see common elements i.e. context, subject, process and action are part of key components of Action research. Commitment and efforts of action researchers to carry out change is part of the research act (McTaggart, 2002).

The main purpose of Action research is to solve a particular issue or problem as well as to produce solutions, guidelines and procedures for best practice (Denscombe, 2010). This is part of an innovative way for improvement of quality of working life and organizational performance (Frank Pot, 2010).

3.3.4 Conclusion

Research methods must be determined and prepared in order to develop and establish the ICT works interface framework. The researcher must prepare preliminary questionnaires that could provide the answer to the issues being raised. The objective of the questionnaires is to gain

information about the ICT Works Interface in a large scale construction-based project. It was prepared as guide with preliminary inquiry checklist to facilitate the researcher to conduct observations, focus group meetings, interviews, and make observation effectively, efficiently and systematic during Action Research in the project case study.

Based on the research questions derived from the statement of the problem, exploring the issues and answer those questions by analysing unstructured data and observations of the phenomenon in the workplace was essential. Therefore, Qualitative Research was the right choice of the research design due to full participatory observation and it was part of the instrument to be exercised whom the researcher was involved directly in the research (Silverman, 2010). The Qualitative research method adopted was to inductive reasoning from individual cases or particular facts to a general conclusion (Ladyman, 2002). The research applied interpretive approaches, concepts and theories that tended to arise from the enquiry.

Data collection and analysis were not tightly separated but rather interweaved and repeated several times as the research progresses. In an interpretive approach, the world was considered to be socially constructed and subjective, and the observer could be part of the system. In relation to the research enquiry, the research strategy was a real-time case study or life case study.

According to Arber (2006), the researcher is also the practitioner in which he will examine his own organizational practice, systematically and carefully. Action Research is also a case study methodology (Westbrook, 1995; Dick, 2002) which involves an exploration within a bounded system with small sample (Silverman, 2010), in this case is KLIACS. KLIACS has few projects, past and on-going which can be adopted as project case to support the Action Research.

Based on the previous discussion, the aim of this research is to develop an ICT Works Interface Framework. The developed framework is expected to be used and implemented in the current and future mega construction project. Therefore, Action Research was the most appropriate research method to be applied because it was a site-based research (Thomas and Quant, 1999).

As conclusion, an Action Research has been proposed and a real-time case study on on-going construction project managed by KLIACS was selected to explore the interfacing process, identified the problems and issues between ICT and engineering, and at the same time solved the problems during the operation of the project.

3.4 Research Design

This section briefs the background of case study research, defines action research methodology and case study technique, and explanation of action research designs as being created from life case study research. As mentioned in

the previous section, Action Research served as the main method by using qualitative case study technique for this study.

Action Research was chosen as the research approach for this study because it is a site-based research. It provides a method to the researcher on how to solve problems or issues as well as to revise professional practices in the researcher's own workplace. It also gives new opportunities to explore new ideas, method, and materials as well as to share them with fellow team member and address the organisational/industry-wide problem. In this research context, it enabled the researcher to explore the interfacing problems, to identify the common works interface between ICT and engineering, engaged with all related parties involved and at the same time solve the problems while the project was underway. A real-live case study i.e. *Development of Centre of Excellent of Malaysian Rubber Board in Sg. Buloh* was chosen to pursue the research where the researcher involved directly as an active participant in the construction project.

During literature review phase, the researcher has found several well-known case study researchers. Among the prominent researchers were Robert K. Yin, Sharan B. Merriam, and Robert E. Stake. All of them had written comprehensively about case study research, and have recommended techniques for organising and conducting such research successfully (Yin, 2014; Merriam, 2009; Stake, 1995).For the purpose of this action research, the definitions presented by David Coghlan and Teressa Brannick (2014) was adopted by the researcher.

3.4.1 Action Research

Coghlan and Brannick (2014) describes Action research as “any research into practice undertaken by those involved in that practice, with an aim to change and improve it”. Therefore, it is an enquiry process by a practitioner into the effectiveness of his/her own professional practice. Action research is about both ‘action’ and ‘research’ and the relations between the two.

Action research involves practitioners in studying their own professional practice and framing their own questions. Their research has the immediate goal to assess, develop or improve their practice. Such research activities belong in the daily process of good teaching, to what has been called the “zone of accepted practice” (Zeni,1998).The original Lewinian stated that the cycle of action research involves a pre-step and three key activities: planning, action and fact finding (Lewin, 1997). The pre-step is a general objective.

Planning is an overall plan and a decision pertaining to steps to be taken. Action comprises of first step, fact findings, evaluation of the first step, observation of lesson learned from the step and creation of the correction of the next step. Thus, action research cycles is a spiral of steps which is form of planning, action and fact-finding of the action.

For the context of doing action research in the project where the researcher is involved, the action research cycle adapted was comprised of :

i) Pre-step: context and purpose, and

ii) Main steps: constructing, planning action, taking action and evaluating action (*Figure 3.2*).

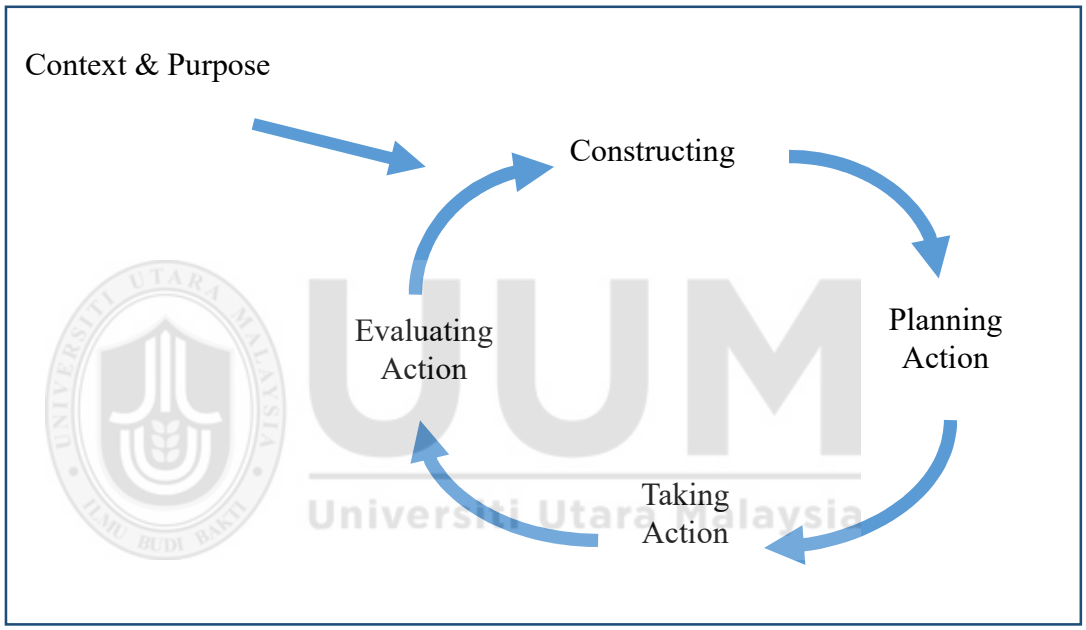

Figure 3.2
The Action Research Cycle. Adapted from Coghlan and Brannick (2012).

In this research study, the action research process started with Context and Purpose which is seeking an understanding the context of the study and identifying why the research is necessary. Constructing is the first step of the action research cycle in which the issues are constructed based on questions and observations done by the researcher about the ICT interfacing problem or issue or difficulty experienced by some or all of the ICT related personals in large scale construction-based project.

The step has to be done meticulously and carefully since it involves articulating the theoretical foundations and practical of action. Working themes are generated as the foundation of which action would be strategized and executed. Planning Action begins from exploration of the context and purpose of the research, and follows construction of the issue, and is consistent with them. Taking Action is the stage where plans are executed and interventions made collaboratively. Evaluating Action is the process where the consequences of the action are examined to see whether the action has been taken in appropriate manner and fitted the original constructing.

This approach encouraged the researcher to look at the actions that are successful so that the good practice could be extended to other interfacing works or project team involving in this or other similar project. The cycle continued as the researcher decided on some actions to examine the question by exploring how the participants see the issue and also how the researcher adapted a different approach in practicing the interfacing.

This has involved the researcher in gathering some evidence in the form of feedback from the participants and also by observation of their work. The process was a simple cycle but more a spiral: reflection on the researcher's action and findings has led to another question and further action, caused a change in the researcher's practice, which in turn looped forward to further exploration and revision as represented in *Figure 3.3.*

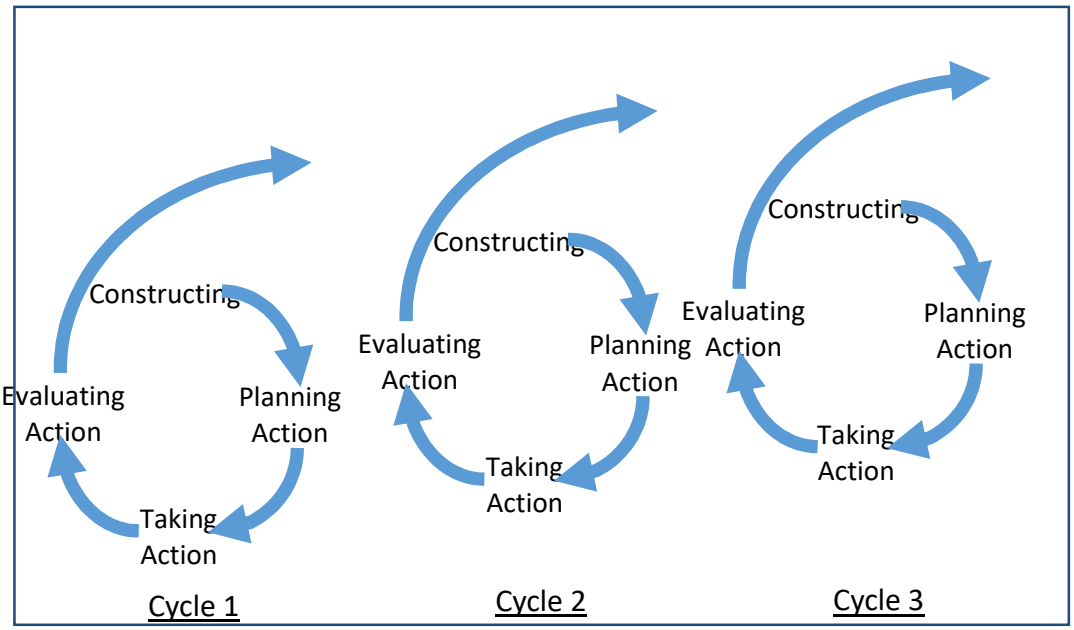

Figure 3.3
Spiral of Action Research Cycles. Adapted from Coghlan and Brannick, (2012).

Action research results remained the property of the researcher and the participants while distribution might be appropriate and of interest to others. The main benefit should be to the researcher and the organisation where the researcher was working.

3.4.2 Case Study

Stake (1995) defined methodology of case study as an inquiry strategy in which the researcher explores an event, program, process, activity or one or more individuals in-depth. Cases are limited by activity and time, and researchers gather detailed information using a range of procedures for collecting data over a continuous period of time.

For this study, the phenomenon under investigation was the ICT works interface in construction project that impacted construction integration. The case for the current study was ICT works interface in one of the construction project carried out by KLIACS, i.e. Development of Centre of Excellent of Malaysia Rubber Board. The researcher collected data through interviews, reviewed project documents, observation and discussion with the focus group i.e. designated team members involved in the project.

Specifically, interviews were conducted using semi-structured questionnaires and later they were transcribed into Word documents. Essential project documents were reviewed such as Project Scope Book and Project Implementation Plan, and data were coded for developing themes. Another component of case studies was the analysis unit which was defined as the focus area of the study (Merriam, 1988; Yin, 2014). In this study, this analysis unit was the individual engineering works involved in the project.

Five (5) components of effective research design of case study produced by Yin (2014) were research questions; propositions or purpose of study; analysis of unit; logic that linked data to propositions; and criteria for interpretation of findings. “How” and “Why” forms of questions were the most appropriate questions for this research which adopted qualitative case study research. Specifically, the researcher asked about the ways the ICT consultants obtained information that informed their decisions on how to carry out the ICT work interface in the construction integration.

Additionally, the researcher inquired as to the ways consultants used the information to make the interface success in the construction project.

Clarification of the research purpose was the second component of research design and it was most commonly recognised as the purpose statement. The main purpose of this research was to understand the activities of the ICT consultants in a construction project as well as to identify interfaces, collaborate with other engineering parties involved and establish the ICT work interface.

The third component of the research design was the analysis unit. Yin (2014) described the analysis unit as the area of focus that a case study analyses. If primary research is accurately specified then it will produce an appropriate analysis unit. The analysis unit was directly linked to the research questions prepared by the researcher. This study of analysis units was the ICT work interface i.e. the case studied by the researcher in the construction project carried out by KLIACS.

Linking data to propositions was the fourth component of case study research design. As themes emerged, this links was made following the data collection phase. As data was analysed, the researcher attempted to match the patterns that appear in the data to the propositions of the case study. The themes that emerged in this study therefore served as answers to the research questions stated in Chapter 1.

Criteria for interpreting findings was the fifth component of case study design. The researcher regularly coded the data prior to developing themes (Yin, 2014). The researcher carefully extracted meaning from the findings to determine recommendations for practice and future research by following the theme development stage.

3.4.3 Research Site

Opportunely, there was no obstacles to locate a suitable site to perform this research. Among several projects being carried out by KLIACS, land development of Malaysia Rubber Board has been selected due to researchers involvement as ICT Project Manager in that project. The nature of the study was to determine the methods that the ICT consultants managed and understood the ICT works. In addition, this research resulted in double the amount of benefits for the researcher as practitioner who was interested in the overall results as well as project consultant. It was exciting when the ICT consultants revealed that this would be an additional piece of project data that they could consider in their mission toward improving ICT work interfaces' goals and initiatives.

Knowing the latter benefit proved that, the findings of this research could contribute significantly to the revision of project's efforts as well as impact ICT works interface positively. The site for this research was a construction of Centre of Excellent of Malaysia Rubber Board in Sg. Buloh, Petaling, Selangor. At the time of the study, the project status was at the

design stage. Since this project has been delayed for quite a long time, therefore, the study of ICT interfaces was not able to be completed till the end of the project. It covered up to the design phase only.

3.4.4 Personals / Participants

Purposeful sampling (Patton, 2002) was utilised to choose the ICT project consultants for developing focus group and personal interviews. The criteria of choice was based on potential of each ICT work to add to the understanding of the processes as well as procedures used to gather the interfacing data.

The selection of personals or participating consultants for this constrained case was not complicated. The intention of the overall research was to know the methods ICT project consultants carried out the ICT interface works in a construction project, therefore, only ICT works that related to building and infrastructure works were included.

The selection of participating consultants for this research was also a strategy of selection in which activities or persons were selected purposefully in order to provide information that could not be acquired from other choices (Maxwell, 2005; Harsh, 2011). Selecting consultants for further discussion in this research was purposeful, as they were the leaders of their respective ICT works, and would understand the process utilised within their works with regard to ICT interfacing works.

In order to achieve a detailed descriptive for the case (Merriam, 2002; Esterberg, 2002), other engineering consultants from different type of discipline within the construction project had been included. Four (4) consultants from four (4) major engineering trade i.e. Architectural, Interior Design, Mechanical and Electrical were the major participants to be interviewed.

3.5 Operational Definition

An operational defines a concept merely in terms of the operations or methods used to produce and measure it. To operationally define the "interfacing" the researcher might look at how many parties were involved in the interfacing process or the researcher might even count the number of engineering disciplines involved in a construction project. With these operational definitions, it provided clarification on the variables involved. Some of definitions might not be acceptable by everyone, however, once it was decided on a particular operational definition for this study, no one could argue about the definition of the concept for this study. With these operational definitions it helped the researcher to communicate about his research concept.

3.5.1 ICT Interface Requirements and Definition

In order to make a workable interface, it is necessary to know the requirements for the works interface and to document them. Interface goals must be clearly defined and elicited to all project participants. One of the aspects that needs to be focused is discipline of requirements engineering

which is vital for interface development and become a major factor in determining the success of the entire integration (Arayici, 2006).Some of the techniques such as requirements engineering risk factors (Keil et al, 1998) and requirements engineering success factors (Hofmann and Lehner, 2001) would be adopted as part of interface definition approach in this research. *Figure 3.4* depicts the structure of Sub-disciplines in requirements engineering inspired by Richard H. Thayer (1997).

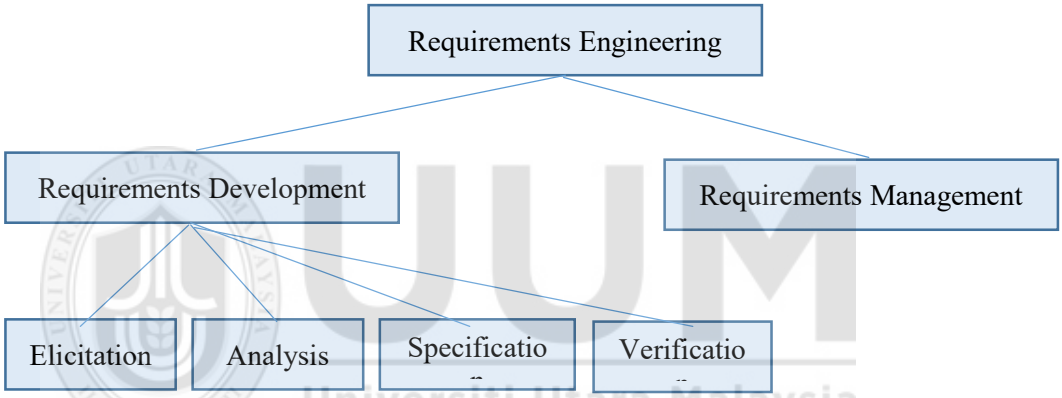

Figure 3.4
Requirements Engineering Structure. Extracted from Sub-disciplines in Requirements Engineering (Thayer, 1997).

3.5.2 ICT Interface Design and Coordination

The effective interface design in construction integration offers important benefits and means to achieve project objectives (Tatum, 1987). An investigation of selected industrial and building projects shall be able to identify the steps participants (progressive owners, designers, and contractors) take to design and map the identified ICT works during the early phases of a project.

Five (5) parameters i.e. *time, technical, geographical, organization*, and *responsibility* (Arayici et al, 2006; Chen, 2007; David, 2006); will be applied for the approach of interface design to classify issues of work interfaces between ICT and Engineering.

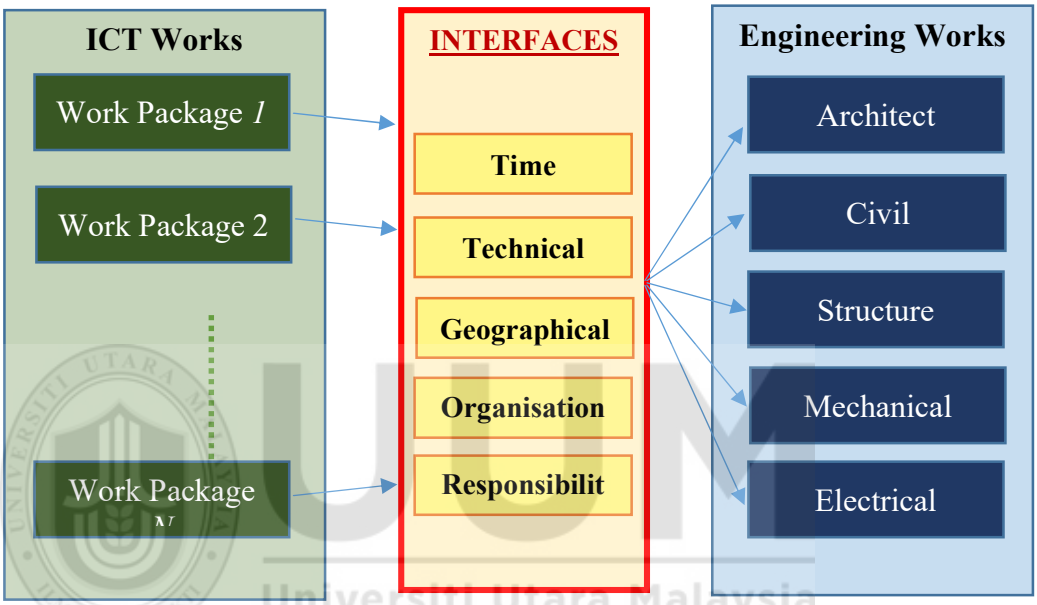

Figure 3.5

Preliminary Interface Design and Coordination Model. Synthesised by the researcher based on Literature Review & Preliminary Study.

Figure 3.5 depicts the preliminary ICT Interface Design and Coordination model based on the preliminary findings of the construction project case. It also describes the major concerns, approaches used, and interface-ability related to the 5 key issues. These findings would provide a basis for motivation of the development of the ICT works interface framework and strategy to revise construction interfaces between ICT works and Engineering works.

3.5.3 Framework Development Procedure

This research aims to develop proven experience-based framework that provides improvement for the interfacing practice of ICT Works in large scale construction-based project. Based on the literature review on the framework development as discussed in Section 2.2 and also research design as described in Section 3.4, participatory action research was the most suitable method adopted for this research which involve action process by the researcher into the effectiveness of his own professional practice. Therefore, Action Research process by Coghlan and Brannick (2014) was chosen as a method for the development of framework which was based on participatory action research, cooperative inquiry and work practice.

Figure 3.6 illustrates the major procedure involved in the framework development which are:

1. Conduct AR Cycle
2. Compile Proven Process of AR Cycle
3. Develop Framework

The first procedure is to conduct the AR Cycle that involves several steps starting with *Context and Purpose* till *Evaluating Action* as described in Section 3.4.1. The number of AR Cycle has to be defined clearly and in this context, it shall be in accordance to the research objectives. The cycle of activities in this procedure has to be kept on moving until the problem solved and the research objective achieved. The next procedure is to analyse and

compile those proven processes or activities involved during the AR Cycle exercise. The proven processes will then be included in the framework development as part of framework structure. The procedure is repeated for the next AR Cycle until the full framework structure established.

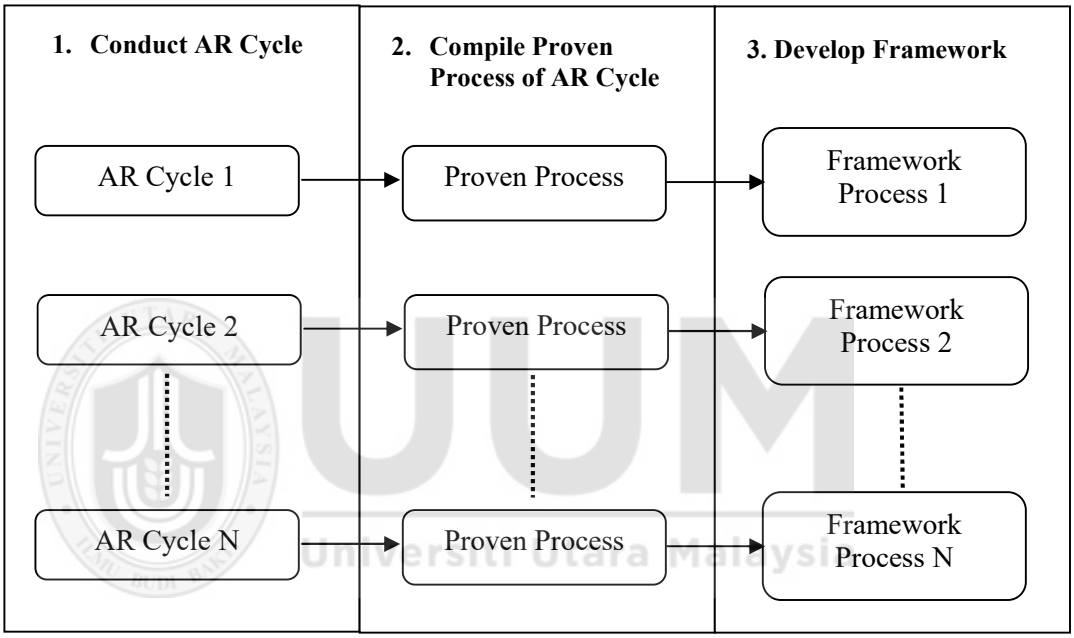

Figure 3.6
Framework Development Procedure

3.6 Data Collection and Procedure

Green, Camilli, and Elmore (2006), agreeing Yin (2014), indicated that, a case study which benefits from having various sources of evidence able to increase the robustness of the study. The concept of method generally refers to the use of appropriate collection of data and analysis techniques (Prasad, 2005).

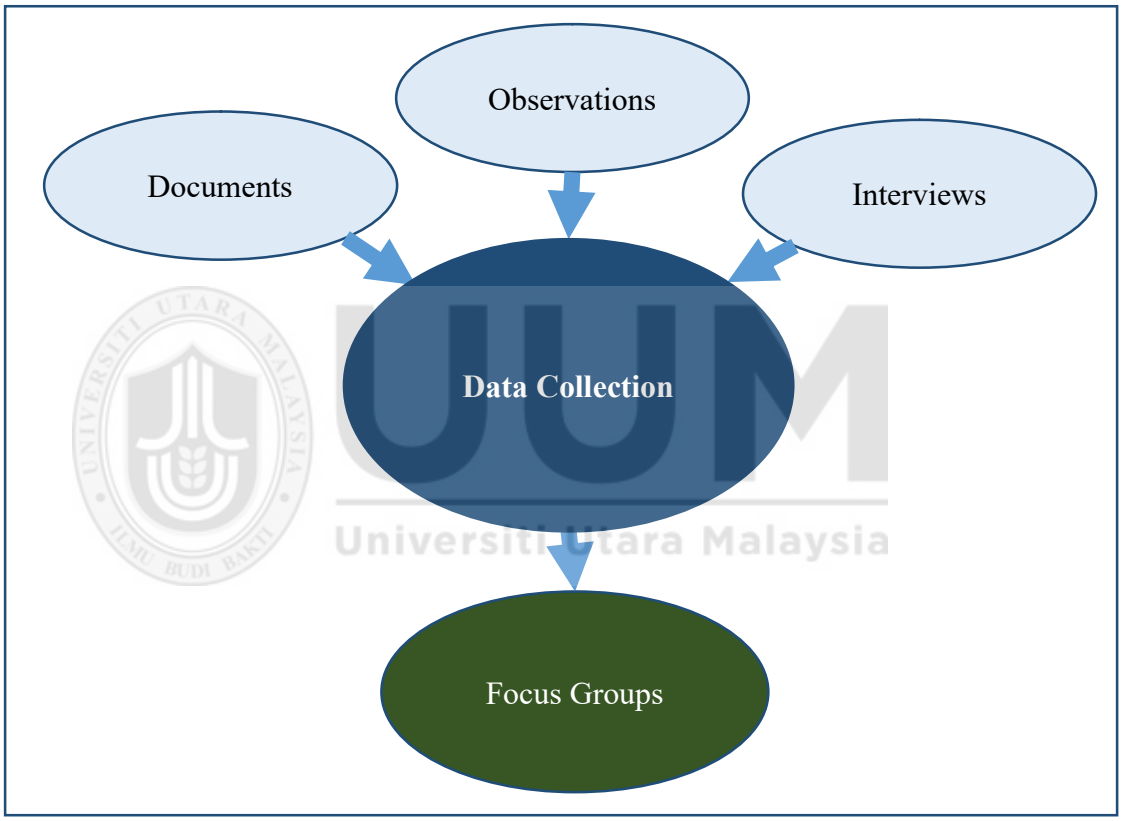

Figure 3.7
Data Collection from multiple sources as convergence of evidence

Figure 3.7 illustrated convergence of data sources, also known as triangulation, is a method to ensure comprehensive outcomes that reflect the participants' understandings as accurately as possible.

Yin (2014) and Stake (2000) concurred that triangulation is vital to the reliability of performance of a case study. Additional sources of data allowed the researcher to create a level that integrated the participants' meaning-making processes. The same view was supported by Seidman (1991), stating that a researcher intent to interview because he or she is interested in other people's stories. Based on this research's scope, which focused on problem solving and solution, the researcher selected Focus Group as an approach for discussing and confirming the data collection.

Project documents such as Scope Book, Project Implementation Plan and Design Drawings were used as primary source of data collection. Interviews were also used to supplement surveys to gain more in-depth information. Focus groups were group discussions and interviews that brought the researcher the ability to capture information more economically than individual interviews (Nagle and Williams, 2013). The third tool was observation, which was used as complementary inputs for information analysis. All these data collection were essentially part of analysis process for the focus group to evaluate, do decision-making, and react in problem solving effort.

3.6.1 Documents

As mentioned earlier, the focus group was part of the data collection method in which project documents were used as the primary source. This was because the context of this research requires project documents as basis for identifying problems in the project interface. In this research, the

researcher interpreted the documents by giving meaning and voice within an assessment topic. The researcher also analysed the documents by incorporating coding content into themes similar to how interview or focus group transcripts were analysed (Bowen,2009).

Document analysis has been used as one of the methods of research and became important research tool in data triangulation which combined several methodologies in the same phenomenon (Bowen, 2009). In this research, the researcher used at least two (2) resources from different sources of data for convergence and validation. The main objective was to provide a convergence of evidence that shows integrity (Bowen, 2009).

The data validation helped to reduce bias by examining data collected through different methods. Project document reviews were adopted in this research to support and substantiate the focus group's statements as well as to provide description of issues and/or problems (Esterberg, 2002; Merriam, 2002).The researcher has to go through a detailed planning process before actual document analysis took place. This was to ensure that the results were reliable. The researcher used 8-step planning process in document analysis as outlined by O'Leary (2014):

1. Prepare list of text to explore (population, samples, participants, respondents, etc).
2. Study how texts will be accessed with attention to linguistic or cultural barriers.

3. Identify and address biases.
4. Build skills for research.
5. Study strategies for ensuring credibility.
6. Know what data to be searched.
7. Study ethical issues (e.g., confidential documents).
8. Prepare a backup plan.

A researcher might use a large number of texts for research such as written documents which was the most common use (O'Leary, 2014). How many documents should the researcher collect was also a question. Wide-range of documents was better, but it should be more about the document quality rather than quantity (Bowen, 2009). Two (2) major issues which had been considered when starting document analysis were bias in the author of the document as well as in researcher, and the unwitting evidence of the document (O'Leary, 2014).

For the bias issue, the researcher had considered the author's personal biases and his subjectivity that he might bring to the research. The original objective of the document, such as the target audience should also be evaluated by the researcher (Bowen, 2009). He should consider whether the author was a first-hand witness or used second-hand sources. It was also important to determine whether the document was solicited, edited, and/or anonymous (Bowen, 2009).

For the second major issue which was the unwitting evidence, or latent content, of the document, it referred to the agenda, style, tone, opinions or facts that presented in the document. The researcher must keep this in mind as a key first step (O'Leary, 2014). Completeness of documents should be assessed to know how comprehensive or selective their data is (Bowen, 2009). When evaluating documents, the researcher has to not to consider the data as necessarily complete, accurate, or precise recordings of events that have occurred (Bowen, 2009). O'Leary (2014)summed up these issues in *step eight process*. This main purpose of *step eight process* is for exploring the witting evidence, or the actual content of the documents (O'Leary, 2014) :

1. Collect relevant texts.
2. Build an organisation and scheme of management.
3. Duplicates the originals for annotation.
4. Asses documents authenticity.
5. Explore agenda of document and biases.
6. Explore information of background (e.g., purpose, style, tone).
7. Query about document (e.g., Who produced it? When? Why? Data type?).
8. Explore content.

In this project case study, the researcher treated the project document like an informant or respondent which provided the researcher with related information (O'Leary, 2014). The researcher "queries" then highlighted the answer within the text. The researcher also noted the content analysis, or

occurrences, where the researcher measured the use of concepts, phrases and particular words (O'Leary, 2014). The researcher, essentially, determined what was being searched for, then documented and organised the amount and frequency of occurrences within the document. The information was then organised into what was being related to the research central questions (Bowen, 2009). Some experts opposed to this kind of analysis. They commented that it obscured the process of interpretive in the case of interview transcriptions (Bowen, 2009). However, documents were various, and analysis of content can be very useful for drawing a picture as a whole (Bowen, 2009).

Content analysis was used as a "first-pass document review" (Bowen, 2009) that able to provide the researcher a way of identifying meaningful and relevant passages. With regard to content analysis, thematic analysis also could also be considered a pattern recognition with the document data (Bowen, 2009). The analysis took emerging themes and made them into categories utilised for further analysis which included careful, re-reviewing and focused reviewing of data, as well as category and coding construction (Bowen, 2009).

The themes and codes might also serve to integrate data collected by different ways (Bowen, 2009). The overall concept of document analysis was as a process of evaluating documents where the empirical knowledge was produced and understanding was developed (Bowen, 2009).Document

analysis is not just a process of listing a collection of passages that takes whatever the researcher wants. The researcher has to uphold high level of sensitivity and objectivity in order to achieve credible and valid results of the document analysis (Bowen, 2009).

There were several reasons why the researcher chose to use document analysis as primary source for developing the research context. Firstly, it was effective and efficient when collecting data as documents were practical resources and manageable. Documents were commonplace, accessible and reliable source of data. Documents were also stable, non-reactive data sources, meaning that they can be reviewed and read repeatedly and remain unchanged by the research process or influence of the researcher (Bowen, 2009).Document analysis was used because it could support and strengthen the research. It could be used as either a primary method of data collection or as a compliment to other methods.

Documents could provide supplementary research data, making document analysis a beneficial and useful method for the research. They provided wide coverage of data and background information, and helpful in contextualizing the research within its field or subject (Bowen, 2009). Document analysis could also point to queries which required to be responded or to situations that need to be observed to ensure the research was critical and comprehensive (Bowen, 2009).

The disadvantages of using document analysis were not so much as they have the potential concerns to be aware of prior to selecting a method or when using it. An early concern to consider was that documents were not formed with data research agendas and thus need some exploratory skills (Triad, 2016). A document might not perfectly provide all of the necessary information that need to answer the researcher's questions. Some documents might provide a small amount of useful data or occasionally none at all while other documents might be incomplete, or their data might be inconsistent or inaccurate, and some might not be easily accessible or available.

For these reasons, the researcher should evaluate the quality of the documents and be ready to face any deficiencies when performing analysis of document (Triad, 2016).Another concern to be mindful of prior to starting the analysis of the document, and to keep attention, was the potential presence of biases, both from the researcher and in a document. The researcher should meticulously evaluate and examine the documents subjectivity and his understanding of data in order to preserve the research credibility (Bowen 2009; O'Leary 2014).

The issues surrounding document analysis could be easily avoided by providing a clear process that includes evaluative measures and steps, as pointed out by the O'Leary's two eight-step processes (O'Leary 2014).The advantages of document analysis might exceed the number of problems that

might arise on condition that the researcher understood what the method are involved and had a clear process planned (Triad, 2016).

3.6.2 Focus Group

The effective interface design in construction integration offers important benefits and means to achieve project objectives (Tatum, 1987). An investigation of selected industrial and building projects shall be able to identify the steps participants (progressive owners, designers, and contractors) take to design and map the identified ICT works during the early phases of a project.

The data collection approach provides a five-stage process for implementing focus group and reporting on the results. The following are the five stages of the data collection approach:

- Purpose of Study
- Conceptualization & Logistics
- Facilitation (Preparation, Pre-Session & Session)
- Analysis
- Reporting

This five-stage process was used as a guide to contribute to the completion of a focus group. Focus Group was chosen due to reason that it provided a deeper understanding of the phenomena being studied and gave insights into how individuals think. Even though open-ended questions might limit the feedback that could be gained from the respondents, they

were still part of valuable research tool to conduct a meeting for the focus group (Nagle and Williams, 2013). Non-verbal communication and group interaction were primary benefits of focus groups. Group interaction among members in the focus group had encourage connections to various concepts over the discussions that might not happen during individual interviews.

The researcher has to encourage the interactions in order to capture the required data as to provide a more comprehensive understanding of what is being studied. In this focus group, non-verbal communication was also be captured. The participants within a focus group might responded differently based on their respective engineering discipline. The interaction was consider as observation data for analytical purposes.

Focus group covers the overall study design and happen when a specific issue has been explored. The methodology of focus group designed for the overall study is described in the following section (Nagle and Williams, 2013).

3.6.2.1 Stage One: *Study Purpose*

Defining the study purpose was the first stage in conducting a quality focus group. It defined how all subsequent activities would proceed, thus, it was very critical. Study purposes for a focus group might include:

- Exploration: Identify issue of importance from the focus group
- Program Development: Asking focus group members what types of activities to do
- Systematic Research: Gathering in-depth data on specific research questions
- Evaluation: Gathering detailed data on specific evaluation questions to determine program progress or success

3.6.2.2 Stage Two: *Conceptualization & Logistics*

a) Conceptualization

The study population and sample were defined after the study purpose had been defined. The population was the ICT works in construction projects. The sample was the ICT Works to be studied which involved in the selected construction project. Focus groups comprised of professionals from multi-engineering disciplines whom form part of the sample. In this research, focus groups did not use random samples or probability. Focus groups utilised accessible sampling.

The sample for a focus group required individuals with the overall population characteristics and it contributed to helping the research gain a better understanding of the issue or topic. A focus group with 7-12 participants was the optimal size to promote discussion and provide problem solutions.

Five (5) questions should be good for an optimal focus group. The researcher should brainstorm to prepare a question listing and then priorities which questions were of maximum significance. The focus group must promote discussion, therefore the questions should be open-ended. Too specific questions or *Yes/No* questions could decrease the significance of a focus group and limit discussion.

After choosing the most important questions, they were then ordered into a logical flow. Prompts for each question also had been prepared which facilitated discussion should there was not a good response to the early question. Probes were also be prepared to explore any issue in more detail. The questions were then finalised and reviewed to make sure that they were aligned with the purpose of the research.

b) Logistics

Preparing to conduct a focus group was quite time-consuming. The researcher started planning about 10 weeks prior to the actual focus group. The researcher had to engage the individuals in a thoughtful process and make changes as needed. Script was the agenda content guiding the researcher to brief to individuals the function of the group as well as objectives to be achieved.

The script support the researcher to ensure that the group was conducted smoothly and in a structured way.

Another thing that need to be aware of was the room. The room shall be comfortable and conducive which should be attended to for a fruitful focus group. The materials was also important and should be organised early. Some materials prepared for focus groups were:

- Focus Group Script/Handout
- Projector
- List of Participants
- Sign-in Sheet
- Refreshments

3.6.2.3 Stage Three: *Facilitation*

The common components of the facilitation stage were preparation, pre-session, and the session itself. There were definite factors to acknowledge for each component that contributed to steering a successful focus group.

a) Preparation

With the logistics completed, the researcher could prepare for the focus group. The researcher should have at least two people. The key person was the facilitator who was the researcher himself and the other was the minutes or note taker. Preparation involved

the facilitator requiring the questions to memory. The script was used for verification but the facilitator had to keep the conversation flowing as reading questions could detract from the conversation.

b) Pre-Session

The time before starting the focus group was an important opportunity to become familiar with the group behaviour. For example, the facilitator could engage in small-talk prior to the session. This has made engaging the group an easier process and helped the participants to feel more comfortable around the facilitator. It also gave the facilitator choice to go where he thought would be most proper based on what he observed during the pre-session. Pre-session was a good opportunity to begin to understand the group and that helped the focus group be successful.

c) Facilitation

After the pre-session, the facilitator continued through the script or handout by first opening the session. The facilitator open the session by requesting the participants to introduce themselves. Sequential introductions should be avoided because this would set the stage for participants to communicate in appropriate manner instead of it being more of a chat.

After opening the session, the facilitator continued through the questions. At the end of the discussion, the facilitator closed the

session using the text from the script. The questions were important but should be maintained flexibility. If problems or issues appear to be important to the participants and in line with the objectives of the research, the facilitator will explore more detail.

3.6.2.4 Stage Four: *Analysis*

The analytical stage was part of the focus group cycle prior to development of report. Analysis began immediately after data had been collected. Summarisation of the discussion with the participants and comprehensive note taking during the focus group session had facilitated more efficient analysis.

The facilitator summarised the themes that were discussed for each question. Data reduction was the key to the analytical stage which summarised a discussion into manageable concepts that facilitated development of report. Whatever method of data summarisation utilized, the facilitator explained it in this research.

3.6.2.5 Stage Five: *Reporting*

The reporting stage bonded all of the earlier stages together for the researcher and the focus group to make decisions on the problems and/or issues. Actions based on the decisions will be carried out to solve the immediate interface problems.

3.6.3 Interviews

As mentioned earlier, interviews were used as part of data collection activities to complement the data sources for this research. Interviews and focus group had been conducted carefully to ensure that the case study was reliable. Therefore, purposeful sampling which included the consideration of a group focus versus an individual, had been considered, and also sample size and relevant consultants as participants to choose for the interviews.

Four reasons for using interviewing were identified. First, qualitative interviewing was suitably used if the researcher want to study people's understanding of the meaning in their live world (Kvale, 1996). Second, the objective of interviewing was to know what was in someone else's mind where the researcher could not find out from them through observation (Patton, 1987). Third, the result of qualitative interviews enable the researcher to make decisions about transferability of study results (Merriam, 2002). Lastly, interviews able to increase the credibility of research findings where information obtained from other sources could be used for triangulation (Emerson, R., et al., 1995; Merriam, 2002).

The interview was often viewed as a conversation between the interviewee and interviewer, in which the interviewee responds accordingly to the interviewer's questions (Esterberg, 2002). The gatekeeper of the knowledge should be identified by the researcher in order to be able to

access the best sources. This was to ensure as rich of a data sample as possible.

In this research, the researcher had identified building architects as the gatekeepers. The first reason was that they were the best people who know about the buildings. Second, the researcher required them to support and cooperate with the focus group especially in the project documents/drawings review. The interviews were conducted in conversational forms where open-ended questions were used. The researcher also shared information about himself with the participants to develop the trust and relationship necessary for this conversation. In this way, it became the respondents at ease, and allowed for an optimal interviewing environment.

Interviewing as Qualitative Research is thematic interviews designed to question the meanings of lived experiences (Seidman, 1998). Seidman connected the core of phenomenology to qualitative philosophy:

"interviewing provides access to the context of people's behaviour and thereby provides way for researchers to understand the meaning of behaviour".

He also recognised that "a basic assumption in in-depth interviewing research is that the meaning people make of their experience affects the way they carry out that experience. Interviewing allows us to put behaviour in context and provides access to understanding their action".

The researcher used a semi-structured interview approach (Merriam, 2002) and a set of open-ended questions to obtain: (a) *the participants' demographic information,* and (b) *perceptions and experiences of participants in ICT interfacing in construction-based project*. The researcher used open-ended questions throughout the interviews to encourage participants to respond freely and openly to queries (Bogdan and Biklen, 2003; Esterberg, 2002; Kvale, 1996). The researcher would use follow-up questions when necessary to clarify or elaborate on a response (Denzin and Lincoln, 2005).

An interview protocol (refer Appendix G) was prepared to ensure the interview questions aligned with the Research Questions. It was an instrument of inquiry that facilitated and guided the researcher to prepare questions for obtaining specific information to the aims of the study (Patton, 2015) as well as an instrument for conversation about a particular topic. Semi-structured open-ended questionnaires for data collection including interviews are attached in Appendix F.

3.6.4 Observation

Observation was crucial part of the data collection method in Action Research. This was because the observation provided the highest level of confidence based on what the researcher saw and experienced in the project case study. Similar to interviews, observation also use semi-structured questionnaire as a guide for obtaining specific information.

3.7 Technique of Data Analysis

Even though observation and focus group were the two (2) method of data collection that consumed most of the time during the course of the research, project documents were also being reviewed. Document analysis was one of the research method and it was part of research tool in triangulation, it combined methodologies in the study of the same phenomenon (Bowen, 2009). In order to seek convergence and validation, qualitative researchers usually use at least two resources from different data sources. The purpose of triangulation was to provide a convergence of evidence that shows integrity (Bowen, 2009).

Qualitative research studies involves a continuous relationship between data collection and data analysis (Strauss and Corbin, 1994). For this reason, the researcher began analysing data following the observation to begin identifying patterns, and to facilitate subsequent data collection (Strauss and Corbin, 1998). Qualitative research is a creative process, not a mechanical one (Denzin & Lincoln, 2000). Similarly, a qualitative study capitalizes on ordinary ways of making sense (Stake, 1995). It identifies and defines the patterns that emerged from that meaning making process. Qualitative data analysis, then, gives meaning to first impressions and final compilations. It is an analysis that tells the story of the researcher's intentions to make informed decisions that define and guide project team success in this project case study.

This research study followed the Creswell's (2009) six steps during the data analysis process and, although these steps are described in linear order, Creswell

described “an interactive practice” to analysis. Meaning, there is a recursive element to following these steps i.e. the process is not simply a static, linear order of analysis.

Step 1: Organize and prepare the data for analysis. During this step, the researcher reviewed field note from observations and project documents, and transferred into Word document transcripts.

Step 2: Read through the data. This step also aligns with Esterberg’s directive to *“get to know your data”* (Esterberg, 2002). The researcher reflected on the overall meaning to gain a general sense of the information and ideas.

Step 3: Begin detailed analysis with the coding process. The researcher followed Creswell’s procedure of organizing the material into segments by taking the text data and segmenting sentences into categories. The researcher then labelled those categories with terms based on the actual language from the participants.

Step 4: Use the coding process to generate a description of the setting as well as categories for these for analysis. The researcher used this process to generate codes for the descriptions, which then led to generalizing a small number of categories or themes.

Step 5: Advance how the description of the themes will be represented in the qualitative narrative. For this step, The researcher wove the emergent themes into

narrative passages, so that the findings emerged logically from the participants' responses.

Step 6: Interpret the meaning of the data. Creswell recognizes that a researcher's own background plays just as important a part of the meaning making process as a researcher's fidelity to a theoretical lens.

3.8 Chapter Summary

In summary, Research methods has been determined and prepared as to develop and establish the ICT works interface framework. Preliminary questionnaires was prepared to answer to the issues being raised. The objective was to gain information about the ICT Works Interface in a large scale construction-based project.

Qualitative Research was adopted due to full participatory observation by the researcher whom involved directly in the research. The researcher was also the practitioner in which he examined his own organizational practice systematically and carefully. An Action Research has been proposed and a real-time case study on on-going construction project managed by KLIACS was selected to explore the interfacing process, identified the problems and issues between ICT and engineering, and at the same time solved the problems during the operation of the project. The research applied interpretive approaches, concepts and theories that tended to arise from the enquiries, discussions and observations. Data collection and analysis were based on the project document review, observations, focus

group meetings and interviews. In this interpretive approach, the research strategy was a real-time case study or life case study.

The aim of this research was to develop an ICT Works Interface Framework. Therefore the framework development procedure has been prepared to ensure that a systematic framework which consists of a detailed process and a practical approach could be established. The purpose of the framework is to make ease of ICT works integration efforts to ICT consultants and contractors involving in construction project. The framework also could contribute to the body of construction integration knowledge in the project management. It is also expected that the framework could be used and implemented in the current and future mega construction project. Based on the research methodology discussed, the expected research findings were :-

1) a similarity criteria and features of common construction integration in Malaysia.

2) a new ICT work interface framework based on requirement engineering and interface coordination. The framework shall be applicable for different type of ICT components.

3) an interface model that help ICT contractors and system integrators to enable and expedite the interfacing processes between ICT works and multi-disciplinary engineering works during construction integration design and development.

CHAPTER FOUR
FINDINGS AND DISCUSSIONS

4.1 Introduction

In the preceding chapter the research methodology was discussed, demonstrating the research framework and methods. It described how the research data would be collected through an action research which combined focus group, document reviews, interviews and observations. The research tools constructed were also included through the research. The research methodology also included the procedures by which the research was executed, including the selection of the case study and the ways of the research study.

In this chapter, findings and analysis of the selected project case study is presented. It discusses responses received from consultants and staffs who involved in the project case study and how these responses were used to answer the research questions. The chapter is arranged into several sections. Section 4.2 describes the Project Case Study selected and participated by the researcher and Section 4.3 describes the inception plan of Action Research. The details of cycles involved in the Action Research are elaborated in Section 4.4, Section 4.5 and Section 4.6. Summary of the chapter is presented in Section 4.7.

4.2 Project Case : Development of MRB's Centre of Excellence Project (2013 – 2020)

4.2.1 Overview

In this section, a real-time case study chosen by the researcher in which the researcher himself directly engaged is discussed. The case study discussed is about the mega construction project owned by Malaysia Rubber Board (MRB) awarded to KLIAA-KLIACS Consortium. MRB is desirous of developing their 535 acres piece of land at Sungai Buloh, Selangor. The piece of land is part of their parcel of land where their present Research Station is situated.

MRB intends to redevelop the land into a world class and latest state-of-the-art facilities to realize their aspiration to be the world's leading reference and research centre for the rubber industry. The project is one of the largest building and infrastructure projects in the country dedicated to meet the business scientific and technological needs of the industry. The project is divided into 7 components mainly:

1) Hevea Tower (Administration Centre)
2) Rubber Research Institute (R&D Centre)
3) Selangor Rubber College (Training Centre)
4) Business Cluster
5) Rubber Discovery Centre
6) Main Infrastructure
7) Information & Communication Technology (ICT)

KLIAA-KLIACS Consortium has been appointed by MRB as the Project Delivery Partner (PDP) to prepare design, tender document and contract documents, solicitations and administration of the contract throughout the project duration. An ICT Unit has been formed to ensure that the implementation of the ICT works is well coordinated. As shown in the project organisation chart (*Figure 4.1*), the ICT Unit consists of various ICT disciplines of consultants/specialists working on the requirements capture and design during design phase as well as supervision during construction phase.

Other units such as Document Controller, Procurement & Contract, Finance & Admin, and Quality Assurance/ Quality Control are the supporting units that will ensure that the ICT work processes follows the project quality management system and quality assurance procedures that have been set up by the project organisation. This is to ensure that quality services are delivered according to specifications and requirements of the construction work.

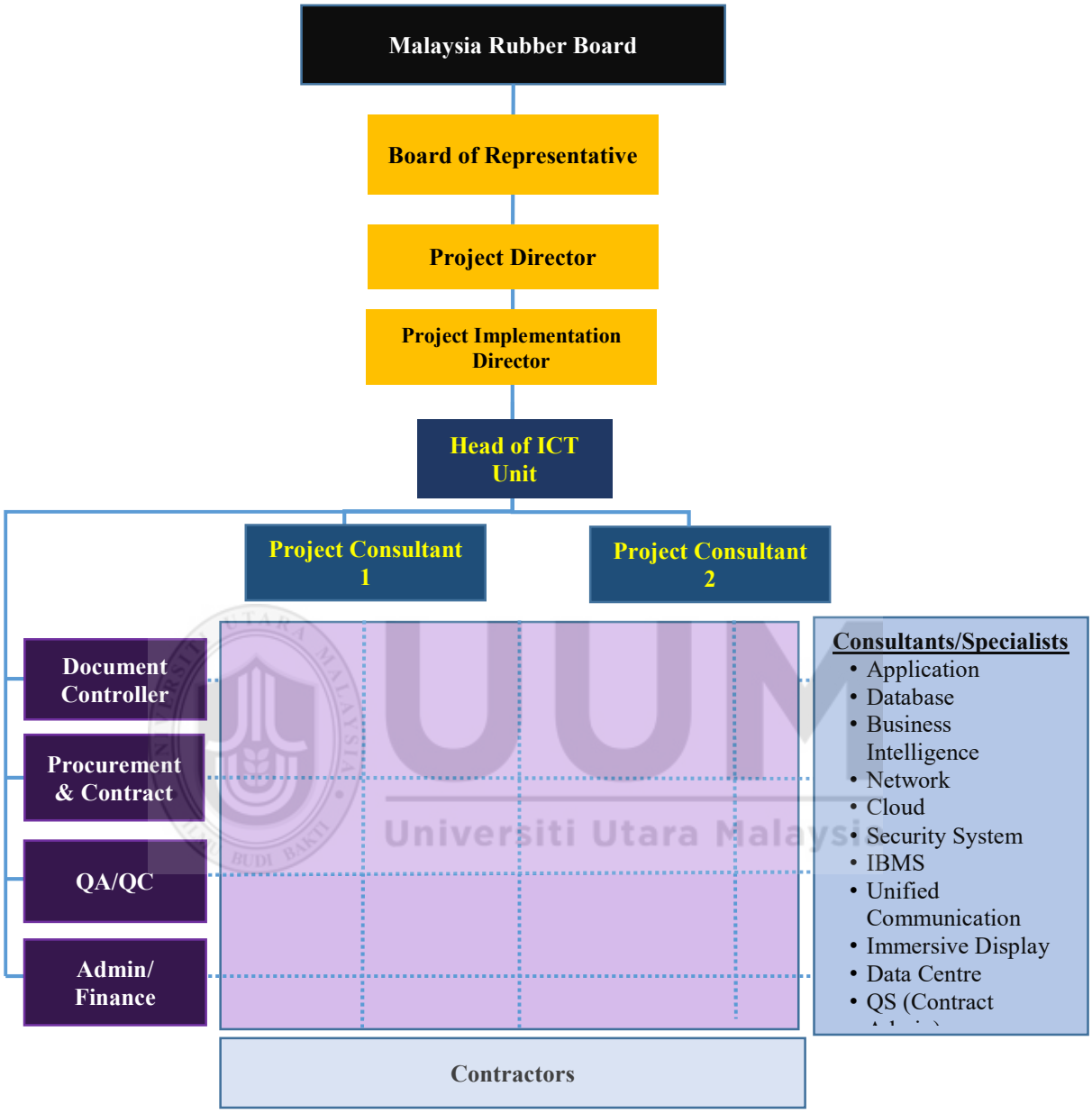

Figure 4.1

ICT Project Organisation Chart. Retrieved from ICT Project Implementation Plan Document (KLIAA-KLIACS Consortium (2014), Development of Centre of Excellence for Malaysia Rubber Board)

4.3 Starting Action Research

4.3.1 Initial Context and Purpose

To start an Action Research, it should begin by defining the context of the research and also the purpose of it. It is very important that every step and action taken is not run from the runway, thus, avoiding the useless and disastrous things. In the early stages of the context definition, the first thing the researcher did was to set the ultimate goal as the destination. This is important to provide a clear direction throughout the journey of Action Research.

The environment should be stated and must be in line with the need for achievement of the goal being established. Each milestone needs to be defined as a short-term objective that needs to be reached one by one until reaching the final goal of destination. As stated in Chapter 1, the researcher has placed research objectives as a destination to develop an ICT Framework for Construction Projects. The purpose was very clear i.e. to develop a framework and its context is the large scale construction base project environment.

One of the objectives of this research study was the revision of ICT works interface in construction base project. Therefore, the study was focused on the interface-ability analysis of ICT works involved in the construction project, ICT components involved, type of construction works and interfacing approach which were based on research question stated in

Chapter 1. Interfacing works in construction project are glue making up an object or product of construction building. In order to perform the interfacing works, interfacing framework provide definitions through combinations of meaningfully arranged steps. Within this general principle, interfacing works in construction project able to constantly evolve.

ICT Works Interfacing was one of the critical jobs carried out during project implementation. But how was the project interfacing to the researcher experiences of ICT works interface involving multi-discipline of engineering works? In this paper, the researcher report on a series of experiences involving finding major interfacing issues in construction project, common engineering interfacing, requirements of interfacing as well as the creation of solution of interfacing problem in ICT works which later form a standard framework for ICT Works Interface for construction project.

To elicit the requirements of ICT Interface Design and Integration, a mega project case study i.e. *Development of Centre of Excellence* (COE) for *Malaysia Rubber Board* (MRB) in Sg. Buloh, Shah Alam, Selangor, was selected. The state of the project was current-case. Requirements, problems and solutions were gained and generated by the focus group which comprise of multi-discipline ICT Consultants who collaborated in numerous intensive, hands-on participatory design workshops/meetings/discussions held at the KLIA Consortium's project site office in *Rubber Research Institute Malaysia* (RRIM), Sungai Buloh, Shah Alam, Selangor.

The ICT Works interfacing processes and discussions about the lessons learned regarding collaborative problem solving of interfacing works in the construction project is presented. All the potential impacts of interfacing process might have at the project design phase is concluded. In this Action Research, three (3) cycles have been defined to explore the ICT works interface involve in this project as well as to identify issues and ways to solve them. The 3 cycles are:

a) *AR Cycle 1*: To explore and discover issues of ICT work interfaces in the Construction Project.

b) *AR Cycle 2*: To explore and discover common interfaces of engineering works in the Construction Project, to examine the ICT works and match them with the Engineering disciplines.

c) *AR Cycle 3*: To define the ICT Interface Plan & Procedure based on the processes explored in the AR Cycle for the development of the ICT Works Interface Framework.

The journey of these cycles are explained in Section 4.4, Section 4.5 and Section 4.6 respectively.

4.3.2 Reviewing Project Documents

Reviewing project documents was the initial step carried out by the researcher to establish the initial research context and purpose. The first document reviewed was the Project Scope Book. This document describes high level of client's requirements scoped by the appointed project developer i.e. KLIA Consortium. The document is compilation and collection of scope

books of major components to be built and delivered by the developer. Every scope book contents three (3) major elements i.e. project objective(s), functional requirements and operational requirements.

The second document reviewed was the Project Implementation Plan. This document states the project's profile such as project objective, budget, implementation strategy, organisation chart, skill set of manpower as well as resource planning for the implementation of the project.

The third document reviewed was the Preliminary Design Document which includes engineering drawings. This documents covers the design concept as well as criteria for the detailed design development.

The fourth document reviewed was the Detailed Design Document which includes detailed engineering drawings. This documents covers the Bill of Quantity (BQ), Technical Specifications as well as Scope of Works to be carried out to deliver the Work Package Contract.

The fifth document reviewed was the project communications and correspondences such as correspondence letters, memos and minutes of meetings which were part of project quality records. Majority of project issues and problems could be found in these documents.

Level of decision making could be recognised based on type of minutes of meetings recorded. Based on the information gathered from those said documents, it gave sufficient understanding on the overall project context and its purpose for the researcher to plan his action research. Table 4.1 shows number of documents reviewed, listed by type of document.

Table 4.1
Total Documents Reviewed

No	Type of Document Drawing	ICT Works	Construction Works
1	Scope Book	1	5
2	Project Implementation Plan	1	1
3	Preliminary Design Document	1	5
4	Detailed Design & Drawings	2	5
5	Project Communications & Correspondences	25	25
	TOTAL	**30**	**41**

4.3.3 Preparing For Focus Groups

Focus groups are ideal for consultation with project stakeholders, enabling the collection of rich information about people's perceptions of their work environment. In the focus groups formed by the researcher, data gathered was qualitative data collection, as such the data was descriptive and most of them could not be measured numerically.

Several reasons for using focus groups were as follow:

- To obtain detailed information and insight into ICT works and engineering works involved in the construction base project.
- To investigate and understand the opinions and issues in ICT works interface in the construction project.
- To generate strategies and solutions for addressing the interfacing issues between ICT and engineering works.
- To establish an ICT works framework based on the research findings and results.

The focus groups set up were taken the following considerations:

1. Size

A focus group needs to be big enough to generate ideas, but not too big that participants feel nervous due to group size or have no chance to make a contribution to the discussion. A small group may cause less energy and lack of diversity in experience. Thus, the researcher has set to have a size of 6 participants for each group in order to reduce difficulty to manage the time and group dynamics.

2. Composition

Two major focus groups had been set up by the researcher to get collaborative ideas and share common interests on the interfacing topics which were ICT Group and Engineering Group as depicted in *Figure 4.2*. Each group comprised of six people who shared their

perceptions and points of view. The researcher personally became the facilitator of the focus groups. The participants of the focus groups were grouped to understand and explore interface issues based on the engineering disciplines in the construction works. In addition, the participants already know each other and have common task goals and similar job roles.

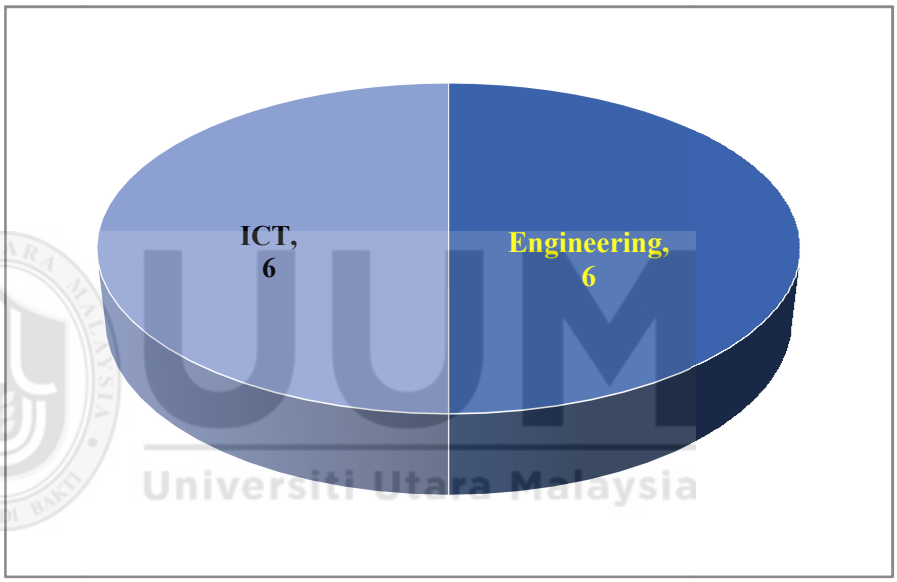

Figure 4.2
Type of Focus Group and number of participants

Table below shows the participants background and their respective group.

Table 4.2
Participants of Focus Groups – ICT and Engineering

ICT Focus Group	Engineering Focus Group
ICT1 – Software Consultant	ENG1 – Architect
ICT2 – System Consultant	ENG2 – Civil
ICT3 – Cabling Consultant	ENG3 – Structure
ICT4 – Network Consultant	ENG4 – Mechanical
ICT5 – IBMS Consultant	ENG5 – Electrical
ICT6 – Security Consultant	ENG6 – Interior Design

3. Duration

The duration of a focus group has been set 60-90 minutes. Shorter session is less effective to assist in the discussion and resolution of issues of the project. If the session is longer, the participants will become tired or bored, and this will make them withdraw from the group. Frequently, the facilitator arrived early to prepare the room and ensure that the necessary devices such as projector was in working order. The participants were asked to arrive 5-10 minutes prior to the session in order to enable the most effective use of time.

4. Location

Since the researcher study was action research, most of the meetings with the focus groups were placed at the project site office. Location is very important to consider in order to ensure messages are delivered to the group more effectively. There were several meeting rooms at the project site office that were always used by the researcher and the project team. The smallest room was the discussion room where it able to accommodate up to 8 people. Seating layout was in the form of U-Shape so that effective and optimal communication could be achieved. The researcher often ensured that the room was booked in advance before a meeting with the focus groups.

5. Materials

In this study, the researcher did not have to worry about material preparation for the focus group as all the involved parties were the project consultants employed by KLIACS. The researcher only provided refreshment because most of the meetings were considered official meetings that dealt with problems and issues of the project interface. Material preparation such as name-tags, notes and pens were not necessary because all participants already know each other and the meetings were part of their scope of works.

4.3.4 In-depth Interviews

In-depth interview was the extended activity of the focus group. It was conducted individually on the relevant participants of the focus group for the issues involving certain discipline that required further investigation. Several interview sessions were carried out separately so that the focus group sessions were not too long which may cause unrelated participants to feel bored or feel their time wasted. As previously stated, this study was an action research type in which the event naturally occurred at the researcher workplace. The participants of the focus group were also consultants appointed by the researcher's company. The in-depth interviews were conducted on the participants who involved with the issues to be resolved. For example, if the issue raised during the focus group session is related to Electrical discipline than further interview will be conducted on the Electrical Engineer who is also the participant of the focus group.

4.3.5 Observations

Observations were carried out by the researcher to see the activities of people involved in the project as well to get understanding on the project organisation chart and level of decision making. This was also part of reaffirmation on the information captured during the meeting of focus groups. Observation was also used as a tool for reaffirmation of project documentation.

4.4 *AR Cycle 1:*To explore issues of ICT work interfaces in the Construction Project

4.4.1 Context and Purpose

The context here is the ICT works in the large scale construction-based project. In this real-time case study, the purpose of the first action research cycle was to answer the research question stated in Section 1.4 as well as to achieve the research goal stated in Section 1.5.It was very crucial for the researcher to understand and determine the context to ensure that he was still within the scope of study and know clearly what to achieve.

As mentioned in Section 1.7, the scope of Action Research had to be limited up to Design Phase only due to major delays occurred in the overall project implementation. In this project context, the Action Research was beginning in the middle of project design phase. During this stage, the high-level Client's Requirement Capture activities had been carried out where the Project Scope Book and Preliminary Design had been produced and submitted for endorsement and approval.

4.4.2 Constructing

After setting the context and purpose, the researcher engaged in constructing what the issues to be raised that would form the basis of which action would be planned and taken. As mentioned in the previous section, the purpose was to explore and discover the issues of the ICT work interfaces in the large scale construction-based project. The construction

project was the real-time case study and became the context that researcher had to engaged within it.

As being informed earlier, the researcher had been involved in this project case study since the project start. Therefore, the researcher actually had already experienced some problems in ICT design especially dealing with interfacing works with other engineering works in this construction project case study. As the first step in the AR Cycle journey, the researcher had prepared an Observation Form to record the current problems. It served as evidence to the problems and as inputs to the action planning process that he needed to take to solve the problems. In order to achieve the objectives set in this context, there were major things to be explored and examined as part of solution and problem solving:

1. How to identify the ICT works?
2. What are the common engineering disciplines involve in the large scale construction project?

4.4.3 Planning Action

Planning action followed from the exploration of the context and purpose of the study, and the issues constructed. The researcher began to explore how to identify the ICT Works, but prior to that, a detailed preparation on the journey to experience the process of establishing the ICT scope of works has had been carried out.

Collaboration with stakeholders and consultants was important to ensure the implementation of action research cycle was in a planned way. As such, to implement the Action Research Cycle 1, the followings had been planned (refer Table 4.3):

Table 4.3

Planning Action for AR Cycle 1

No.	Issues	Data Required	Methods	Plan for Action
1.	How to identify the ICT works?	ICT Scope of works ICT Components Type of ICT disciplines	Document Review Observations	Review Project Scope Book. Observe and discuss with project consultants and client.
2.	What are the common engineering disciplines involve?	Scope of Construction Works Type of Engineering disciplines	Document Review Observations	Review Project Scope Book. Observe and discuss with project consultants and client.

4.4.4 Taking Action

The first action taken by the researcher was reading the Project Documents. As mentioned earlier that the Action Research began during the Design phase was progressing, therefore, it was easier for the researcher to obtain some of the information or documents which had already prepared as inputs for this study. Furthermore, the researcher himself had been involved since the project began.

The first project document read by the researcher was the Project Scope Book which included seven (7) major components or facilities to be developed by KLIAA-KLIACS Consortium as the Project Delivery Partner. The Project Scope Book was the manifestation of the Client's needs statements captured by KLIAA-KLIACS Consortium. ICT Scope Book was part of the Project Scope Book which had been reviewed by the researcher to examine the scope of ICT works involved in the construction project. The researcher had captured the ICT requirements which were quoted from the ICT Scope Book.

The scope book outlined the ICT objectives, functional requirements as well as facilities required to support both operational and objectives. The scope book was compilation of inputs from ICT Questionnaires, meetings and communications between KLIAA-KLIACS Consortium and Malaysia Rubber Board during User Requirement Capture phase.

4.4.4.1 Key Findings for the ICT Works:

Summary of the ICT objectives defined in the ICT Scope Book is as follows:

1) Objective #1: Paperless

"To provide Paperless Office work environment in which the use of paper is eliminated or greatly reduced. The ICT facilities including software and hardware provided shall support the transformation of paper-based to paperless. The facilities

provided shall capable to facilitate a minimum of 90% paperless work environment."

2) *Objective #2: Hevea Data Centre & Cloud Computing*

"To provide Data Centre that house computer systems and associated components, such as servers, telecommunications and storage systems for all MRB facilities in Sg Buloh. The Data Centre provided shall be at least Tier 2 level and comprise of Main Data Centre and Backup Data Centre. "

3) *Objective #3: Integrated Security Management System*

"To provide an Integrated Security Management System at all MRB facilities for preventing unauthorized access to a restricted or controlled area, facility, equipment, material, and documents."

4) *Objective #4: Virtual Reality Environment and Interactive Display System*

"To provide Virtual Reality Environment (VRE) and Interactive Display System (IDS) as part of eye-catching elements to attract more visitors come to MRB. The VRE provided shall be at least 4D and configurable to variety of themes."

5) *Objective #5: Research Central Database*

"To provide Research Central Database for housing records of lab works, e-books, e-journals, e-papers, e-reports or any electronic form of researchers' materials published by MRB."

6) *Objective #6: Hevea Monitoring Centre*

"To provide Remote Monitoring and Controls of related Mechanical & Electrical (M&E) utilities and laboratory equipment. The system provided shall support building automation and laboratory automation."

7) *Objective #7: ICT Infrastructure – Data, Voice & Video Communications*

"To provide ICT Infrastructure comprising of data, voice and video communications for supporting the ICT objectives mentioned above and overall MRB business operations."

Based on the ICT Objectives taken from the ICT Scope Book, the researcher then identified type of ICT components involved in each ICT Objective. Table 4.4 shows the outcomes of the study.

Table 4.4
ICT Objectives and their components

Item	ICT Objectives	ICT components identified
1.	*Objective #1: Paperless*	Document Management System, Digital Signage
2.	*Objective #2: Hevea Data Centre & Cloud Computing*	Data Centre, Computing Server
3.	*Objective #3: Integrated Security Management System*	CCTV, Access Control, Application Software
4.	*Objective #4: Virtual Reality Environment and Interactive Display System*	Virtual Reality, Augmented Reality, Hologram, Immersive Display, Interactive Display
5.	*Objective #5: Research Central Database*	Central Database, Portal Application
6.	*Objective #6: Hevea Monitoring Centre*	Operation Centre, Integrated Building Management System
7.	*Objective #7: ICT Infrastructure – Data, Voice & Video Communications*	Network Cabling, Network System, IP Telephony

4.4.4.2 Key Findings for the Construction Works:

In this research context, type of engineering disciplines of each facility were identified and highlighted. Summary of the Construction Works defined in the Project Scope Book is displayed in the following table.

Table 4.5
Type of Construction Work in the Project

Item	Construction Works	Type of engineering discipline involved
1.	Construction of Rubber Research Institute	Architecture Civil Structure Mechanical Electrical Interior Design Landscape **ICT**
2.	Construction of Hevea Tower	Architecture Civil Structure Mechanical Electrical Interior Design Landscape **ICT**
3.	Construction of Rubber College	Architecture Civil Structure Mechanical Electrical Interior Design Landscape **ICT**
4.	Construction of Rubber Discovery Centre	Architecture Civil Structure Mechanical Electrical Interior Design Landscape **ICT**

Table 4.5 *(continued)*

Item	Construction Works	Type of engineering discipline involved
5.	Construction of Ancillary Building including Masjid, Central Store and Fleet Management Centre.	Architecture Civil Structure Mechanical Electrical Interior Design Landscape **ICT**
6.	Construction of Main Infrastructure including other amenities and civil works.	Architecture Civil Structure Mechanical Electrical Landscape **ICT**

Table 4.5 shows type of engineering disciplines identified by the researcher in each of construction works in this project case study. The collected data shows that all construction works especially buildings shared common engineering disciplines in their construction works. The shared common engineering disciplines are as follows:

- Architecture
- Civil
- Structure
- Mechanical
- Electrical
- Interior Design
- Landscape
- ICT

The key findings to be addressed here is that the ICT works exist in all type of construction works.

4.4.4.3 Key Findings for the Interfacing Works:

Based on the researcher's observations, some relevant information had been collected and compiled, as a result, a high-level of collaboration between ICT and engineering had been interpreted. *Figure 4.3* illustrates the ICT discipline in the middle position has to collaborate with all common engineering disciplines in the construction project. This was the first level of ICT Interfacing in the construction project.

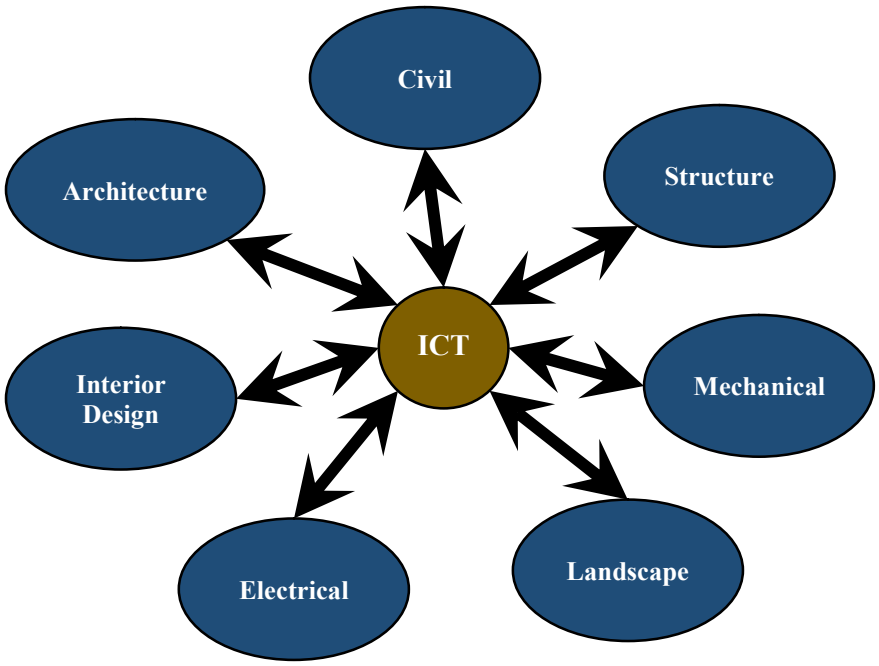

Figure 4.3
First level of ICT Interfacing – ICT and Engineering. Synthesised by the researcher based on compilation of data collection.

The high-level interfacing only showed who are the parties that the ICT team need to be collaborated for the interfacing works. At this stage, it was still difficult for the researcher and the ICT team to know what type of interfacing involve in the project. During this stage, the ICT components of the ICT objectives had been grouped into the following Work Package Contract (WPC):

a) Digital Office
b) Cloud System
c) Data Centre
d) CCTV Security System
e) Card Access System
f) Interactive & Immersive Display System.

g) Integrated Building Management System
h) Operation Centre
i) Network Cabling
j) Network System
k) Unified Communications & IP Telephony

The researcher then went to the next level of interfacing where he tried to breakdown the ICT components and map them with the engineering disciplines as shown in the *Figure 4.4*.

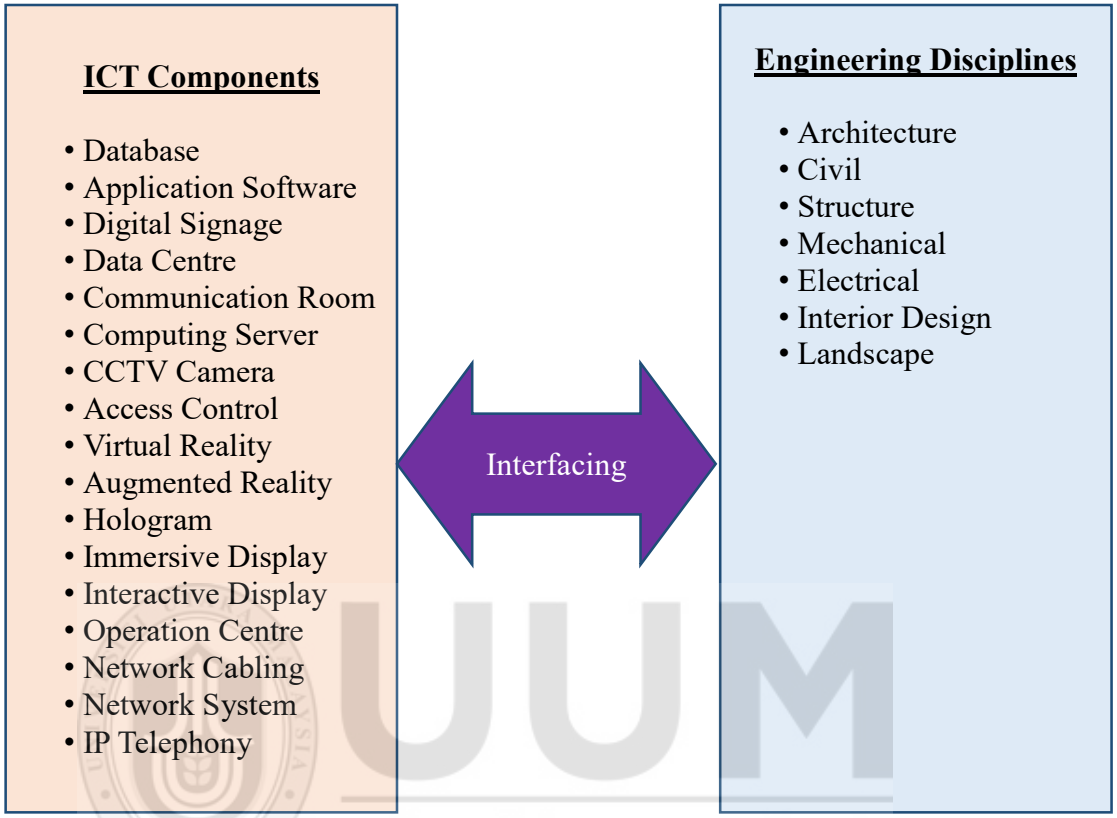

Figure 4.4
Second level of ICT Interfacing – Mapping the ICT components with the Engineering Disciplines. Synthesised by the researcher based on compilation of data collection.

4.4.5 Evaluating Action

Evaluating action involved reviewing on the result based the actions taken in the AR Cycle 1 whether the objective was achieved or not. The researcher also reviewed the process and made necessary modification if needed.

Table 4.6
Evaluating Action for AR Cycle 1

No.	Issues	Plan for Action	Result	Revision Made
1.	How to identify the ICT works?	Review Project Scope Book. Observe and discuss with project consultants and client.	The researcher managed to identify and list the ICT works found in the construction project.	Observation and discussion with project consultants and client had been eliminated. Capturing the ICT works was included as part of Action Plan to expedite the process of identifying ICT works in the project.
2.	What are the common engineering disciplines involve?	Review Project Scope Book. Observe and discuss with project consultants and client.	The researcher managed to identify and list the engineering disciplines involved in the construction project.	Observation and discussion with project consultants and client had been eliminated. Capturing the Enginnering works was included as part of Action Plan to expedite the process of identifying Engineering works in the project.

Table 4.6 describes the result of AR Cycle 1 and the revision made during the iteration of actions.

Figure 4.5 illustrates the revision made during the iteration of actions in AR Cycle 1 till the objective achieved. The researcher had created Project Review Form as review instrument to record relevant data captured during project review. Observation and discussion with project consultants were eliminated and replaced by Capture the ICT works and Capture the Engineering Disciplines.

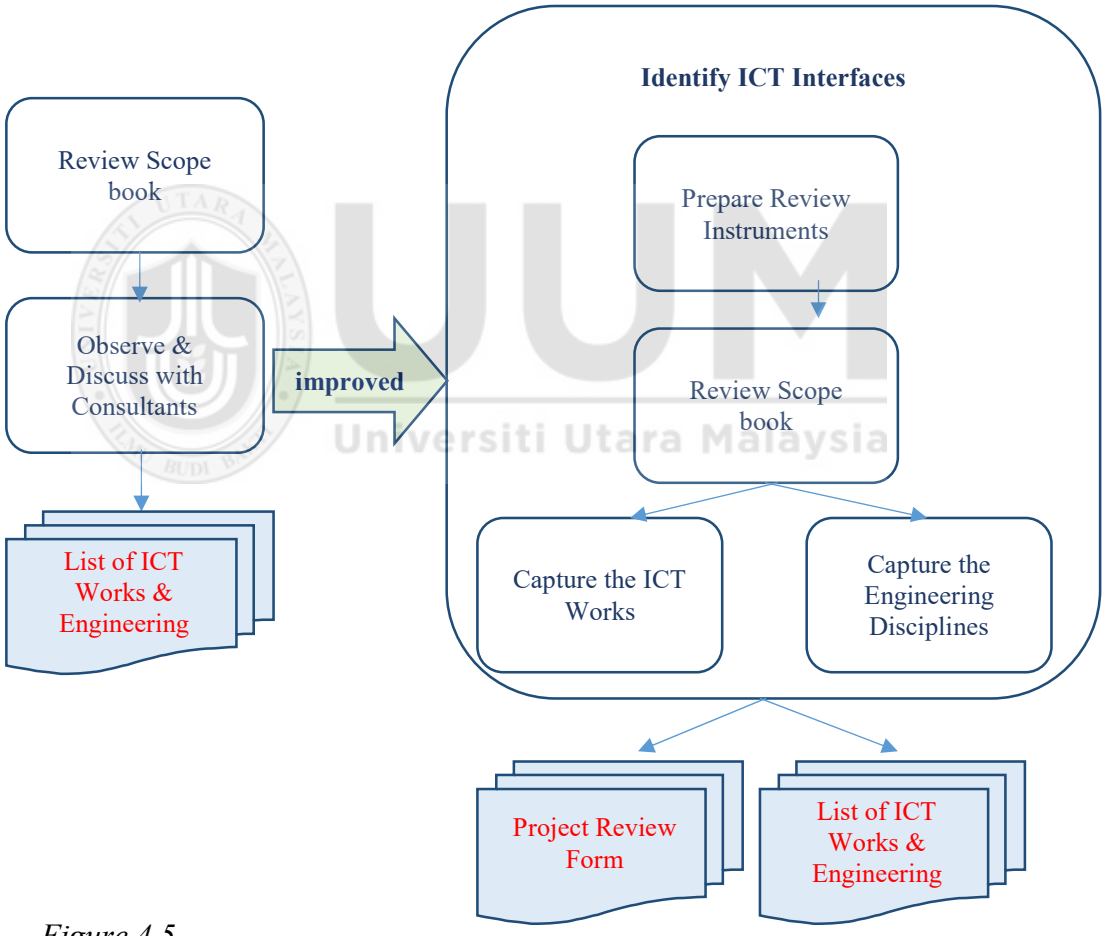

Figure 4.5
Action Revision in AR Cycle

4.5 *AR Cycle 2*: To explore common interfaces of engineering works in the Construction Project, to examine the ICT works and to match them with Engineering disciplines

4.5.1 Context and Purpose

The goal of *AR Cycle 2* was to identify type of ICT interface works that match with the engineering works. This was very crucial to know the coordination of works between various components of ICT and multi-engineering disciplines existed in the construction project as well as to revise in terms of interfacing constructability between ICT and Engineering.

4.5.2 Constructing

The main point to be emphasised in constructing the issues was the coordination of interfacing works between ICT and Engineering. In order achieve the coordination points, detailed information on the ICT works for each components need to be examined and matched with the Engineering disciplines.

Based on the researcher's observations, it was found that one of the causes of coordination issues was the lack of information gained by the ICT Consultants as no staff was acting as the interface manager/coordinator.

In order to achieve the goal set in this context, the following question need to be answered, explored and examined as part of solution and problem solving: “How to map the ICT works with Engineering disciplines?”

4.5.3 Planning Action

In this planning action, the researcher had proposed and produced a quality record template which was ICT Interface Register. This was an effort by the researcher to tackle the issues highlighted in the previous section as part of revision and problem solving to be implemented in *AR Cycle 2*.

Table 4.7
ICT Interface Register Template

No.	Template Name	Particular ofData
1.	ICT Interface Register T a b	• Name of ICT Work Package • Name of ICT Trade • Name of ICT Component • Type of Engineering disciplines matching with the ICT work • Type of interfacing (to be mapped withType of Engineering Disciplines)

Table 4.7 describes the details of ICT Interface Register to be used by the researcher together with the focus group.

A plan for implementing the *AR Cycle 2* had also been prepared as described in Table 4.8.

Table 4.8
Planning Action for AR Cycle 2

No.	Issues	Data Required	Methods	Plan for Action
1.	How to map the ICT works with the Engineering disciplines?	Type of Construction Works. Particular of works in each ICT Component. Type of Engineering disciplines.	Focus Group In-depth Interview Document Review Observations	Review ICT Preliminary/Detailed Design. Meeting with the ICT consultants in Focus Group sessions. Special sessions with each ICT Consultant discipline for in-depth discussions. Observe the communication aspects among the project consultants.

4.5.4 Taking Action

The researcher began with collecting ICT data and registering ICT works interface using the ICT Interface template prepared earlier. To make sure the interface work registration run smoothly, the researcher has had a meeting with the ICT Focus Group to brief on the implementation of the ICT Interface template.

The first thing the researcher did was identifying the ICT Interface. The researcher then further examined the component or equipment of ICT works to be carried out and installed. Type of construction work package in which the ICT works to be carried out and components to be installed were also being identified and registered. Once the nature of ICT works were identified and examined, they were then mapped with the Engineering disciplines which share the same place or area to work together to perform a function.

4.5.4.1 Results of the Identification of ICT Works Interface and Mapping:

ICT Component #1: Application Software

The Application Software was one of the components in the Digital Office Work Package. It was part of *ICT Objective #1* i.e. Paperless. Based on the examination done by the focus group, they agreed that this component was operational and had nothing to do with the construction activity.

Therefore, the result was “none of Engineering discipline can be mapped with it”. *Figure 4.6* shows that no link between ICT component and Engineering disciplines.

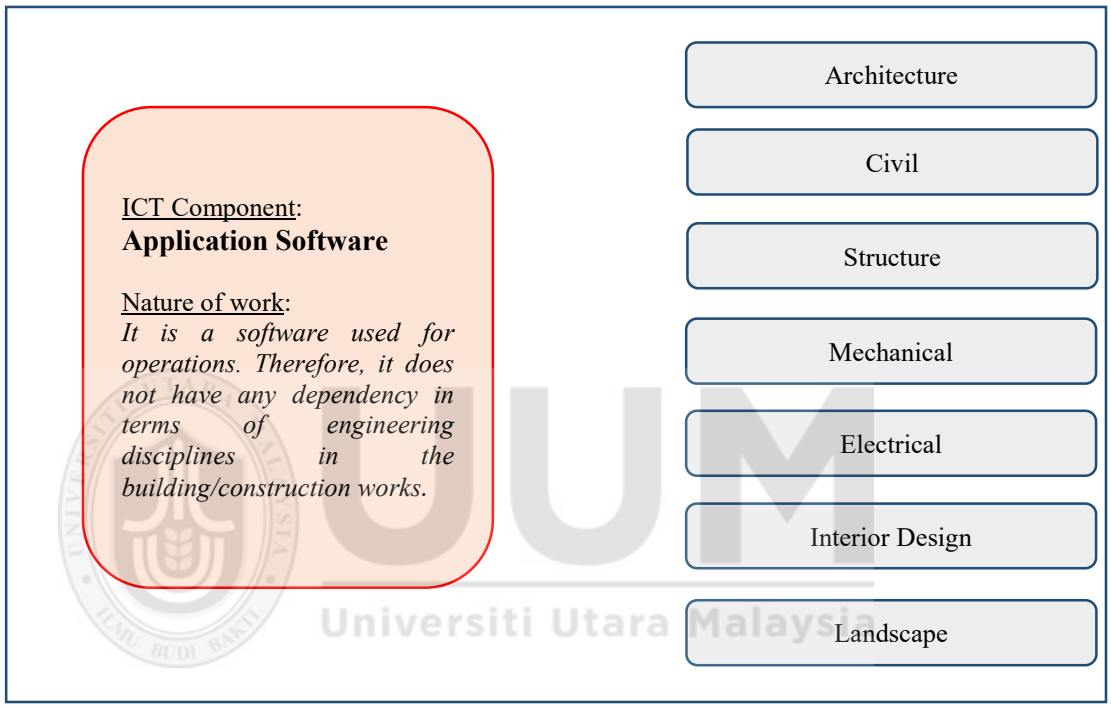

Figure 4.6
Identification of ICT Interface and Mapping – Application Software

ICT Component #2: Database

The Database Software was one of the components in the Digital Office Work Package but it was actually part of *ICT Objective #5* i.e. Research Central Database. Based on the examination done by the focus group, they agreed that this

component was operational and had nothing to do with the construction activity.

Therefore, the result was “none of Engineering discipline can be mapped with it”. *Figure 4.7* shows that no link between ICT component and Engineering disciplines.

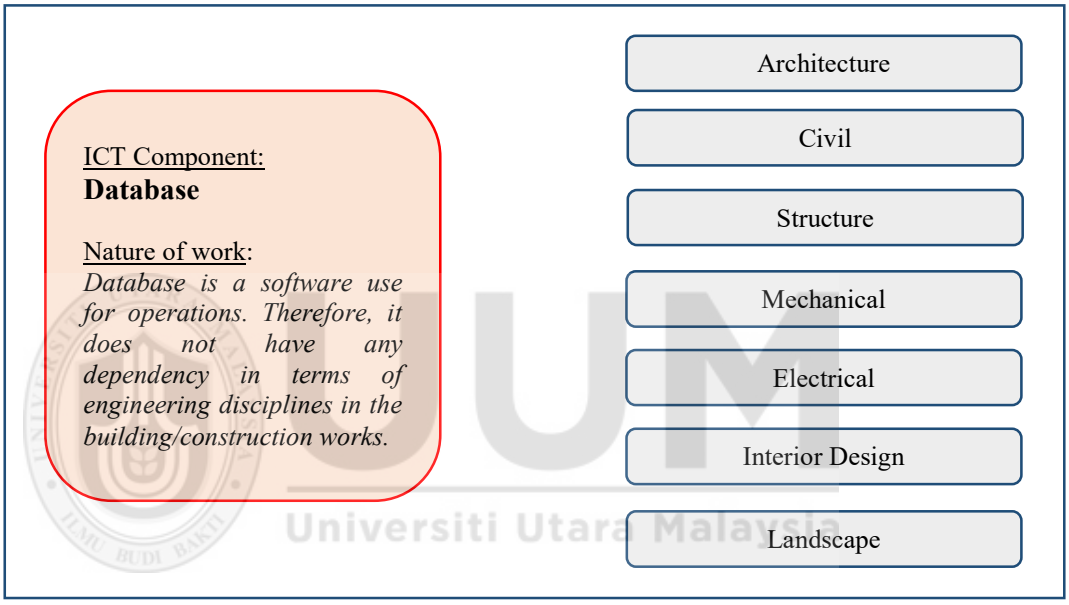

Figure 4.7
Identification of ICT Interface and Mapping – Database

ICT Component #3: Digital Signage

The Digital Signage comprised of LCD displays that served as digital bulletin board supporting the paperless office environment. It was included in the Digital Office Work Package and to achieve the *ICT Objective #1* i.e. Paperless.

Based on the examination done by the focus group, they found that the Digital Signage required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *structure* to mount and support the display device, therefore, coordination with *Structure Consultant* was required;

c) *electrical power*, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Digital Signage can be mapped with Architect, Structure, Electrical and Interior Design". *Figure 4.8* shows the links between ICT component and Engineering disciplines.

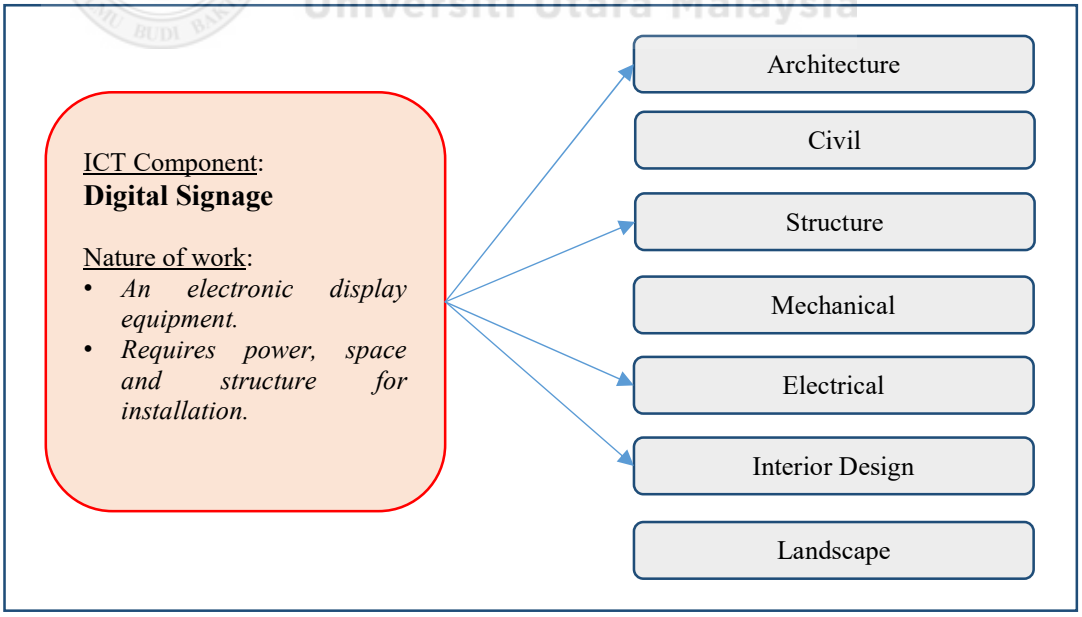

Figure 4.8
Identification of ICT Interface and Mapping – Digital Signage

ICT Component #4: Data Centre

The Data Centre was a facility to house computing server, storage system, communication devices, electrical power genset, precision air-conditioning, raised floor, and various of security and safety system to support its operation. It was included in the Data Centre Work Package and part of the *ICT Objective #2* i.e. Hevea Data Centre and Cloud System.

Based on the examination done by the focus group, they found that the Data Centre required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *infrastructure works such as trenching and ducting* to lay optical fibre for data communication, therefore, coordination with *Civil Consultant* was required;

c) *structure* to load and mount heavy components such as electrical power genset and air-conditioning, therefore, coordination with *Structure Consultant* was required;

d) controlled air-conditioning room, therefore, coordination with Mechanical Consultant was required;

e) *electrical power* for its electronic devices, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Data Centre can be mapped with Architect, Civil, Structure, Electrical, Mechanical and Interior Design". *Figure 4.9* shows the links between ICT component and Engineering disciplines.

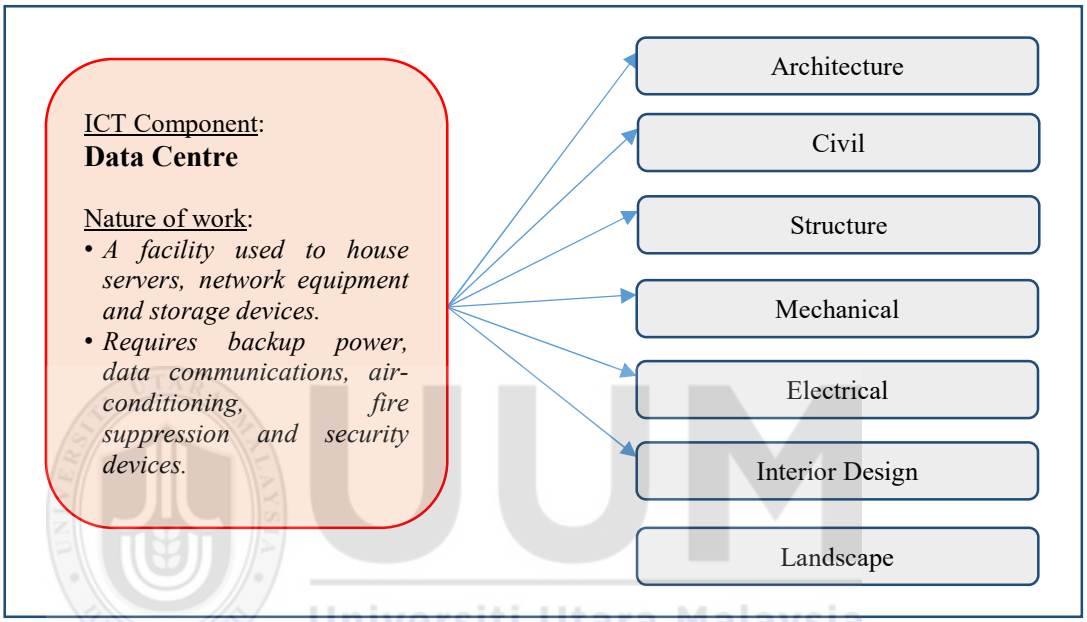

Figure 4.9

Identification of ICT Interface and Mapping – Data Centre

ICT Component #5: Computing Server

The Computing Server was included in the Cloud System Work Package and part of the *ICT Objective #2* i.e. Hevea Data Centre and Cloud System. Based on the examination done by the focus group, they found that the Computing Server required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *structure* to mount the server machine, therefore, coordination with *Structure Consultant* was required;

c) *controlled air-conditioning room,* therefore, coordination with *Mechanical Consultant* was required;

d) *electrical power* for the server machine, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Computing Server can be mapped with Architect, Electrical, Mechanical and Interior Design". *Figure 4.10* shows the links between ICT component and Engineering disciplines.

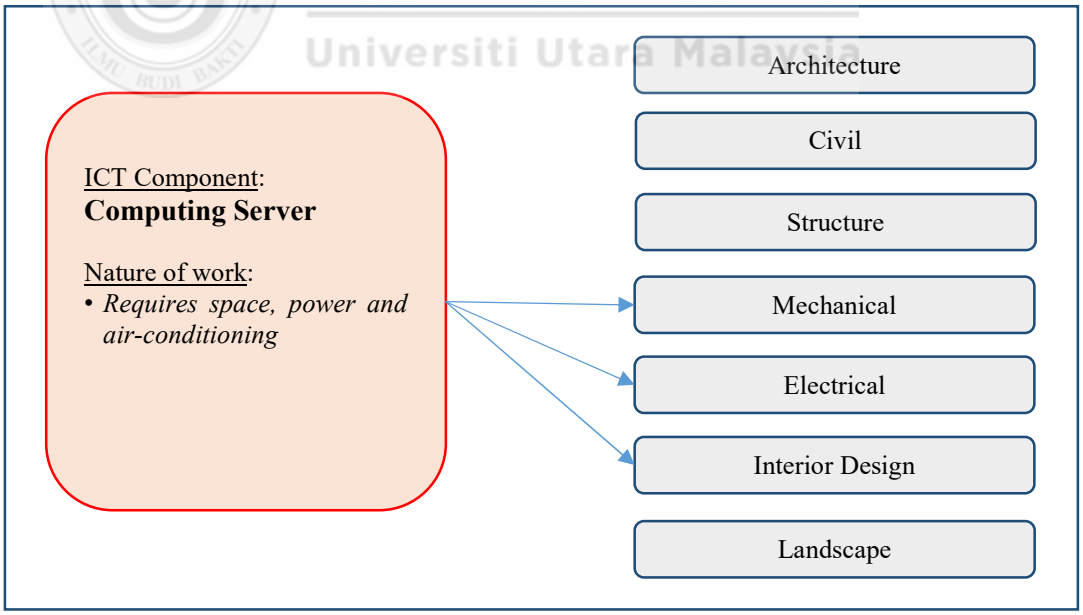

Figure 4.10
Identification of ICT Interface and Mapping – Computing Server

ICT Component #6: Close Circuit Television Network (CCTV)

The CCTV System was included in the Integrated Security Management System Work Package and part of the *ICT Objective #3* i.e. Integrated Security Management System. Based on the examination done by the focus group, they found that the CCTV System required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;
b) *infrastructure works such as trenching and ducting* to lay power cable and optical fibre for data communication, therefore, coordination with *Civil Consultant* was required;
c) *provide footage/video input for Building Control System,* therefore, coordination with the *Mechanical Consultant* was required;
d) *electrical power* for the CCTV devices, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the CCTV System can be mapped with Architect, Landscape, Electrical, and Interior Design". *Figure 4.11* shows the links between ICT component and Engineering disciplines.

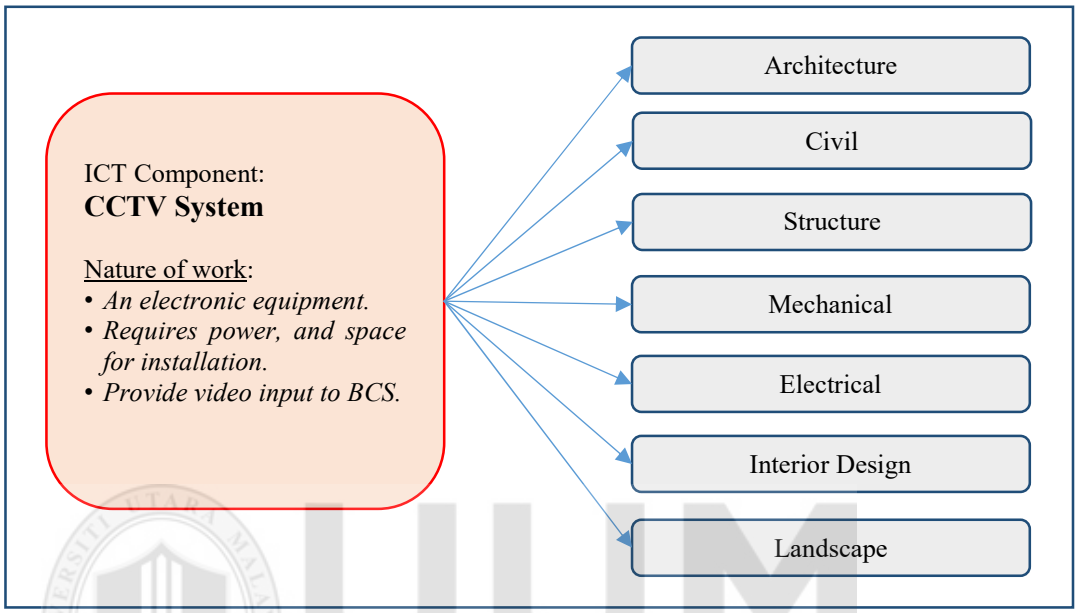

Figure 4.11
Identification of ICT Interface and Mapping – CCTV System

ICT Component #7: Access Control System

The Access Control System was included in the Integrated Security Management System Work Package and part of the *ICT Objective #3* i.e. Integrated Security Management System. Based on the examination done by the focus group, they found that the Access Control System required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *infrastructure works such as trenching and ducting* to lay power cable and optical fibre for data communication, therefore, coordination with *Civil Consultant* was required;

c) *electrical power* for the Access Control devices, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Access Control System can be mapped with Architect, Civil, Landscape, Electrical, and Interior Design". *Figure 4.12* shows the links between ICT component and Engineering disciplines.

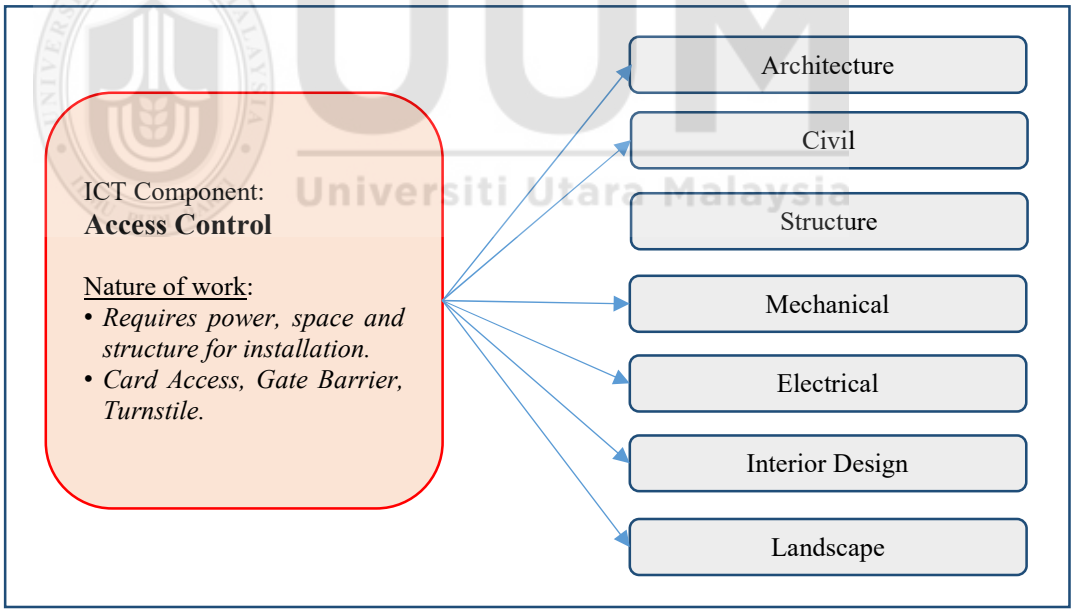

Figure 4.12
Identification of ICT Interface and Mapping – Access Control System

ICT Component #8: Virtual Reality System

The Virtual Reality System was included in the Immersive & Interactive Display System Work Package and part of the *ICT Objective #4* i.e. Immersive & Interactive Display System. Based on the examination done by the focus group, they found that the Virtual Reality System required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *viewing distance* from the display screen require some *space* and should not be blocked by the building columns, therefore, coordination with *Structure Consultant* was required;

c) *air-conditioning environment,* therefore, coordination with *Mechanical Consultant* was required;

d) *electrical power*, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Virtual Reality System can be mapped with Architect, Structure, Electrical, Mechanical and Interior Design". *Figure 4.13* shows the links between ICT component and Engineering disciplines.

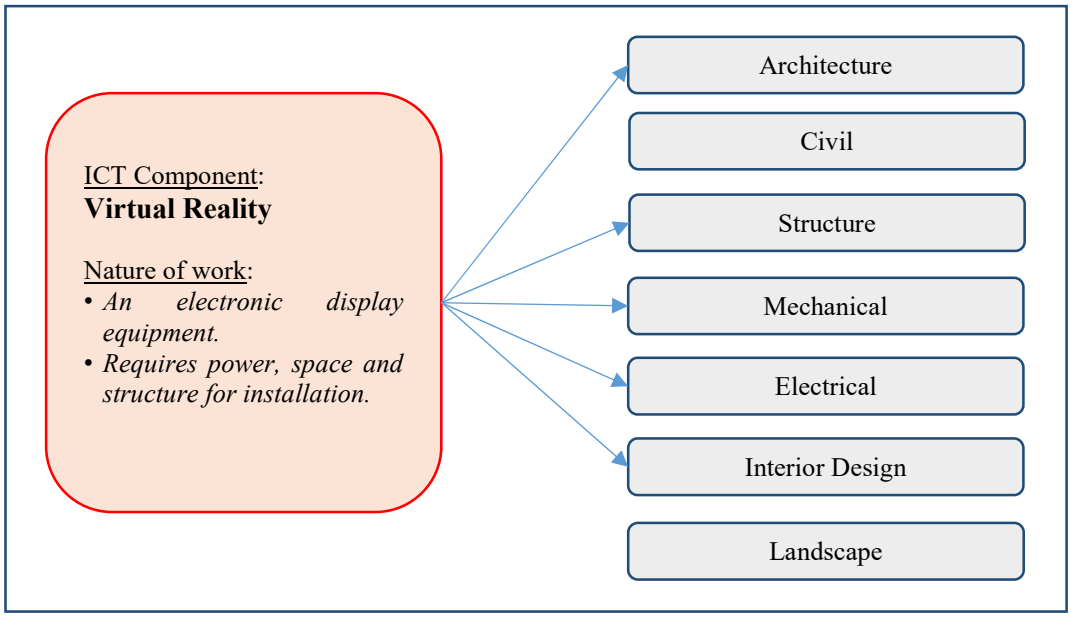

Figure 4.13
Identification of ICT Interface and Mapping – Virtual Reality System

ICT Component #9: Augmented Reality System

The Augmented Reality System was included in the Immersive & Interactive Display System Work Package and part of the *ICT Objective #4* i.e. Immersive & Interactive Display System.

Based on the examination done by the focus group, they found that the Augmented Reality System required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *viewing distance* from the display screen require some *space* and should not be blocked by the building columns, therefore, coordination with *Structure Consultant* was required;

c) *air-conditioning environment,* therefore, coordination with *Mechanical Consultant* was required;

d) *electrical power*, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Augmented Reality System can be mapped with Architect, Structure, Electrical, Mechanical and Interior Design". *Figure 4.14* shows the links between ICT component and Engineering disciplines.

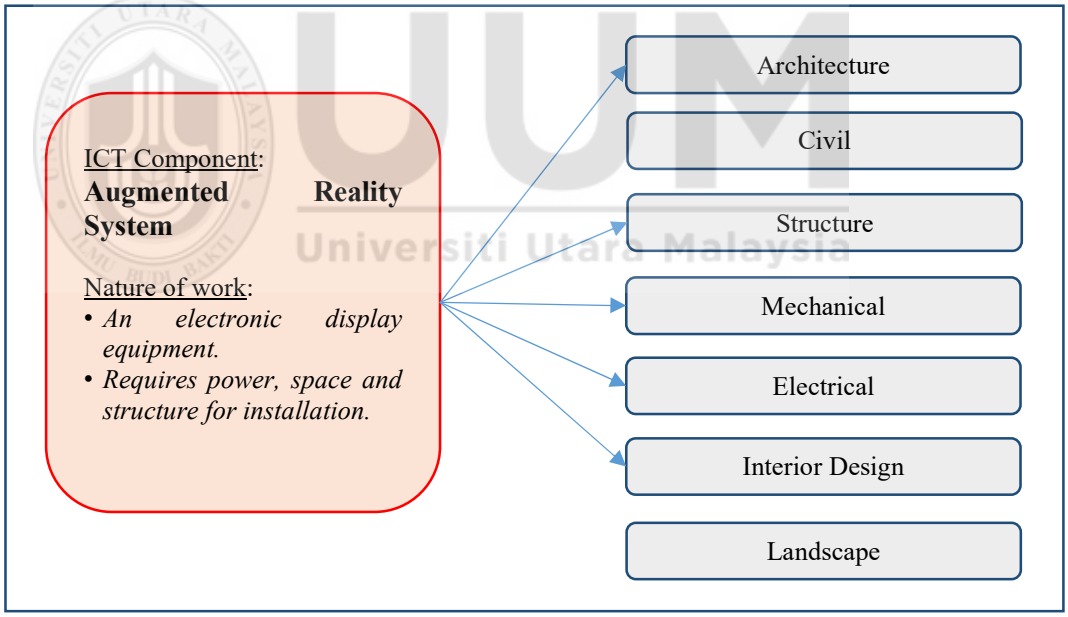

Figure 4.14
Identification of ICT Interface and Mapping – Augmented Reality System

ICT Component #10: Hologram System

The Hologram System was included in the Immersive & Interactive Display System Work Package and part of the *ICT Objective #4* i.e. Immersive & Interactive Display System. Based on the examination done by the focus group, they found that the Hologram System required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *viewing distance* from the display screen require some *space* and should not be blocked by the building columns, therefore, coordination with *Structure Consultant* was required;

c) *air-conditioning environment,* therefore, coordination with *Mechanical Consultant* was required;

d) *electrical power*, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Hologram System can be mapped with Architect, Structure, Electrical, Mechanical and Interior Design". *Figure 4.15* shows the links between ICT component and Engineering disciplines.

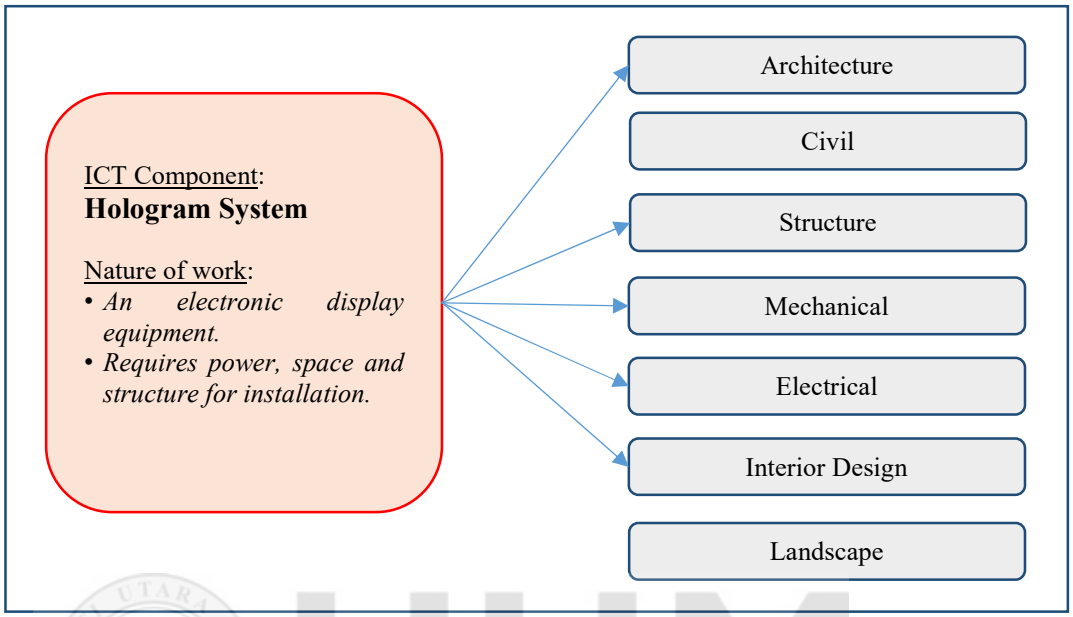

Figure 4.15

Identification of ICT Interface and Mapping – Hologram System

ICT Component #11: Immersive Display System

The Immersive Display System was included in the Immersive & Interactive Display System Work Package and part of the *ICT Objective #4* i.e. Immersive & Interactive Display System. Based on the examination done by the focus group, they found that the Immersive Display System required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *viewing distance* from the display screen require some *space* and should not be blocked by the building columns, therefore, coordination with *Structure Consultant* was required;

c) *air-conditioning environment,* therefore, coordination with *Mechanical Consultant* was required;

d) *electrical power*, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Immersive Display System can be mapped with Architect, Structure, Electrical, Mechanical and Interior Design". *Figure 4.16* shows the links between ICT component and Engineering disciplines.

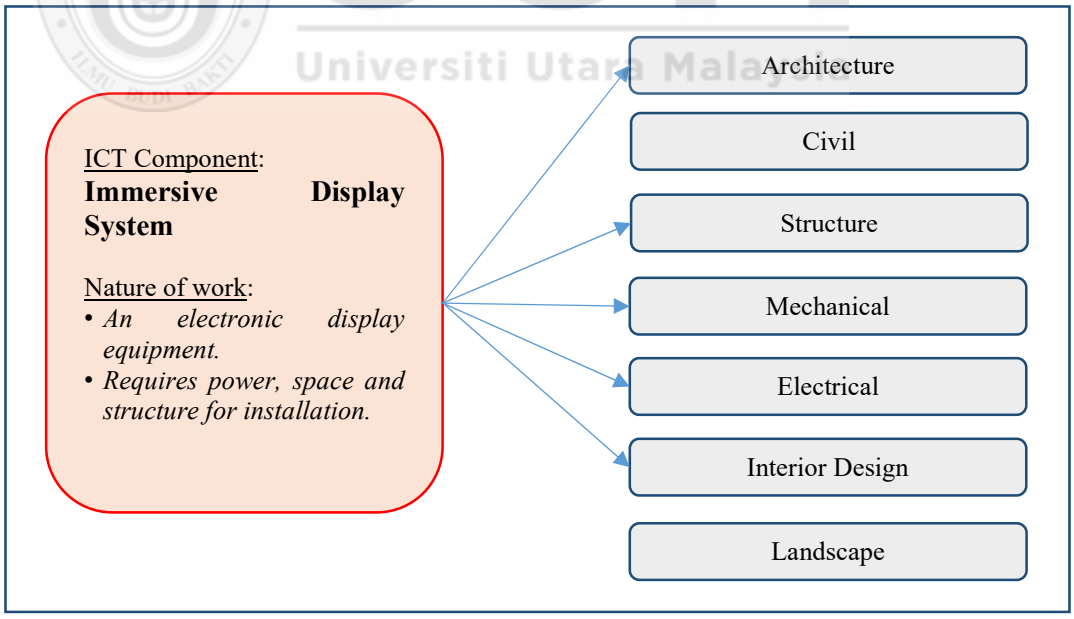

Figure 4.16
Identification of ICT Interface and Mapping – Immersive Display System

ICT Component #12: Interactive Display System

The Interactive Display System was included in the Immersive & Interactive Display System Work Package and part of the *ICT Objective #4* i.e. Immersive & Interactive Display System. Based on the examination done by the focus group, they found that the Interactive Display System required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *viewing distance* from the display screen require some *space* and should not be blocked by the building columns, therefore, coordination with *Structure Consultant* was required;

c) *air-conditioning environment,* therefore, coordination with *Mechanical Consultant* was required;

d) *electrical power*, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Interactive Display System can be mapped with Architect, Structure, Electrical, Mechanical and Interior Design". *Figure 4.17* shows the links between ICT component and Engineering disciplines.

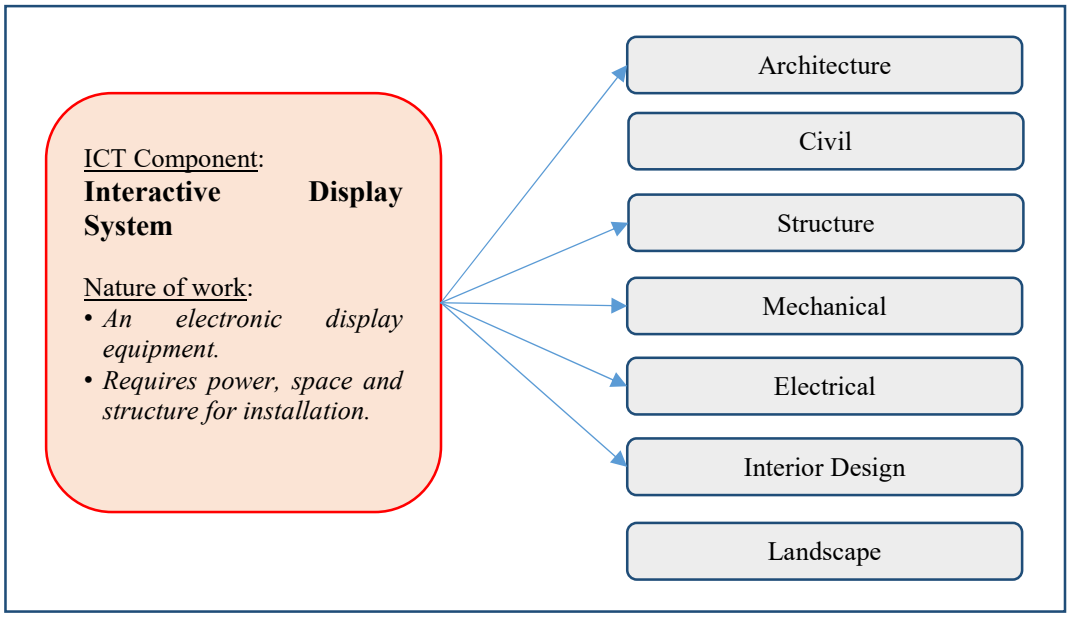

Figure 4.17
Identification of ICT Interface and Mapping – Interactive Display System

ICT Component #13: Operation Centre

The Operation Centre was included in the Operation Centre Work Package and part of the *ICT Objective #6* i.e. Hevea Monitoring Centre. Based on the examination done by the focus group, they found that the Operation Centre required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *viewing distance* from the monitoring display screen and conducive workstations require some *space* and should not be blocked by the building columns, therefore, coordination with *Structure Consultant* was required;

c) *air-conditioning room,* therefore, coordination with *Mechanical Consultant* was required;

d) *electrical power and lighting*, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Operation Centre can be mapped with Architect, Structure, Electrical, Mechanical and Interior Design". *Figure 4.18* shows the links between ICT component and Engineering disciplines.

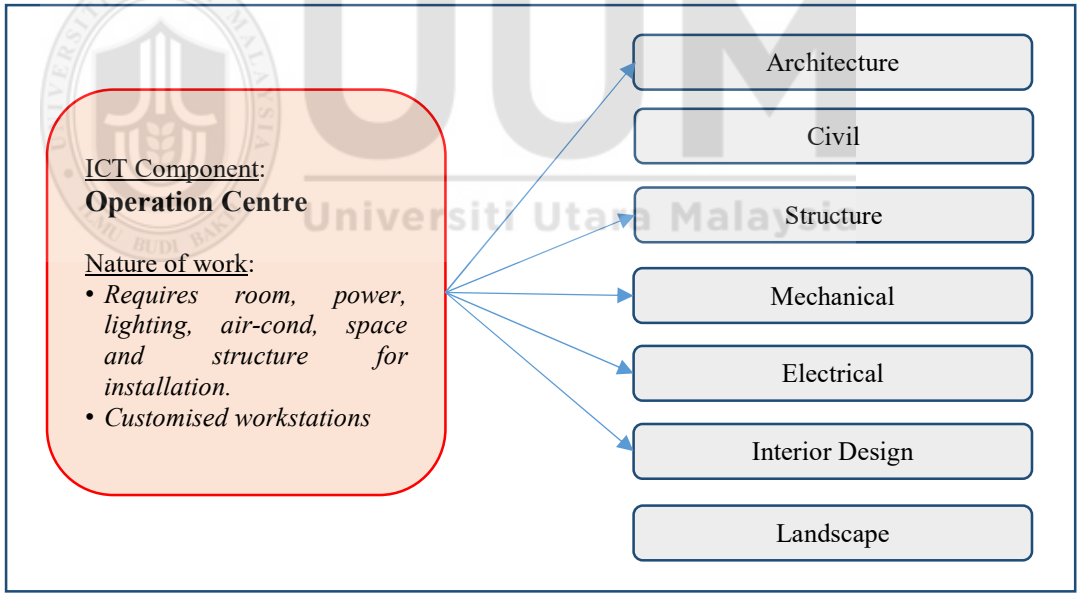

Figure 4.18
Identification of ICT Interface and Mapping – Operation Centre

ICT Component #14: Integrated Building Management System

The Integrated Building Management System is a system comprising hardware such as Direct Digital Controller (DDC) and building management software which was included in the Integrated Building Management System Work Package and part of the ICT Objective #6 i.e. Hevea Monitoring Centre. Based on the examination done by the focus group, they found that the Integrated Building Management System required the followings:

a) massive installation of DDC;
b) massive integration with selected controllable lightings, Security System and M&E services such as chillers, air-conditioning, Air Host Unit, etc. therefore, coordination with Mechanical and Electrical Consultant was very crucial;
c) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

Therefore, the result was "the Integrated Building Management System can be mapped with Architect, Electrical, Mechanical and Interior Design". *Figure 4.19* shows the links between ICT component and Engineering disciplines.

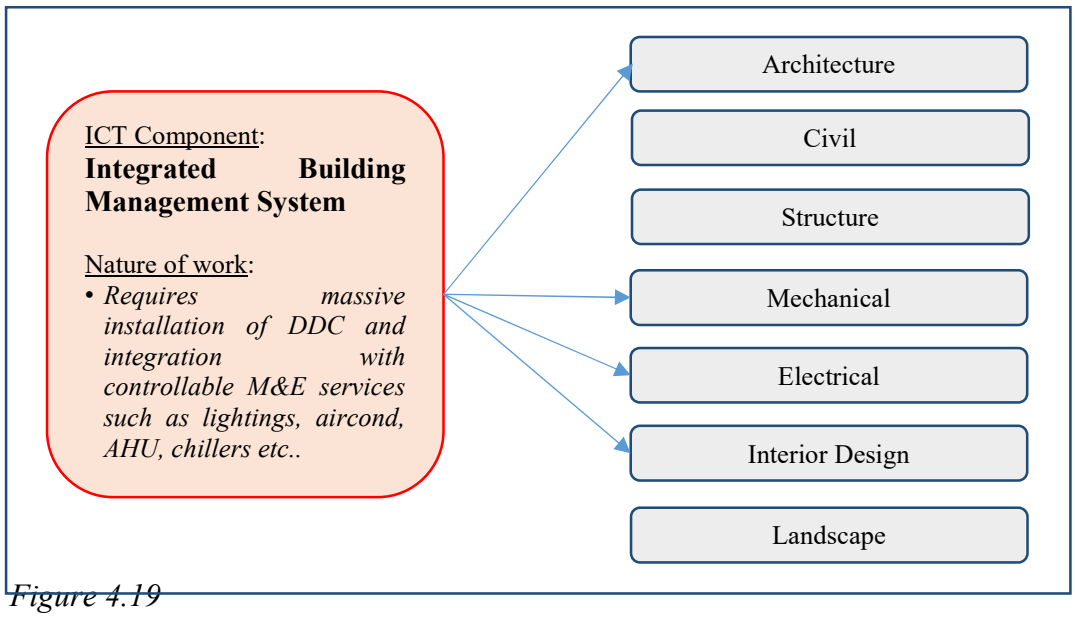

Figure 4.19

Identification of ICT Interface and Mapping – Integrated Building Management System

ICT Component #15: Network System

The Network System comprised of network switches, Wireless-Fidelity (Wi-Fi) and other control devices to provide data, voice and video communication system. It was included in the Network System Work Package and part of the *ICT Objective #7* i.e. ICT Infrastructure – Data, Voice & Video Communications. Based on the examination done by the focus group, they found that the Network System required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;

b) *electrical power* for the Network devices, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Network System can be mapped with Architect, Electrical, Mechanical and Interior Design". *Figure 4.20* shows the links between ICT component and Engineering disciplines.

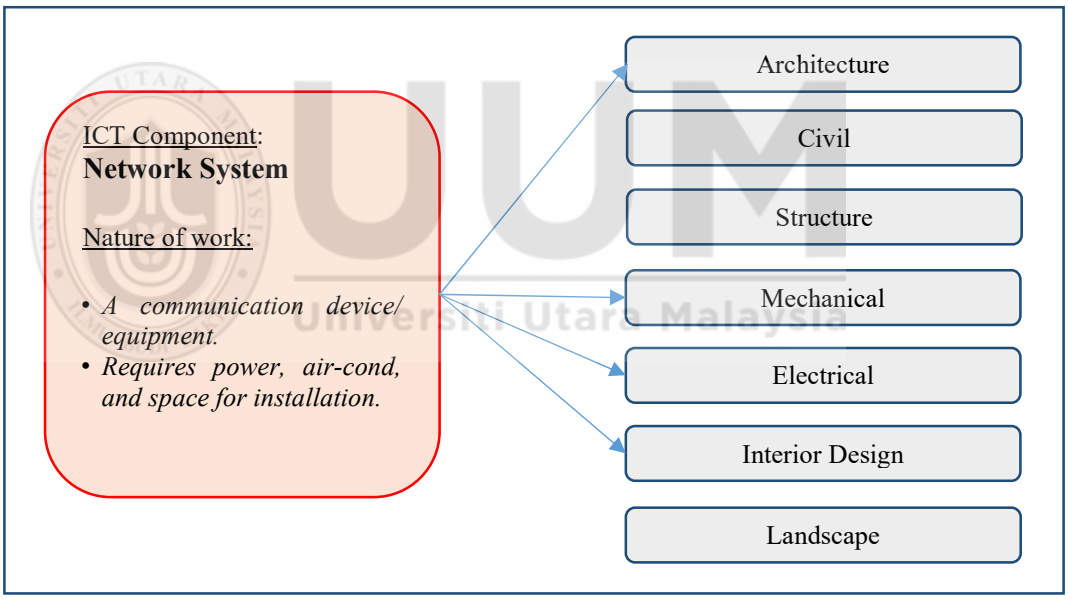

Figure 4.20
Identification of ICT Interface and Mapping – Network System

ICT Component #16: Unified Communication & IP Telephony

The Unified Communication & IP Telephony comprised of Desktop IP Phone, Communication Server, and other control devices to provide voice and video communication system. It was included in the Unified Communication Work Package and part of the *ICT Objective #7* i.e. ICT Infrastructure – Data, Voice & Video Communications. Based on the examination done by the focus group, they found that the Unified Communication & IP Telephony required the followings:

a) determined *location* and *space* for installation, therefore, coordination with *Architect* and *Interior Designer* of the building was required;
b) *electrical power* for the Network devices, therefore, coordination with the *Electrical Consultant* was required;

Therefore, the result was "the Unified Communication & IP Telephony can be mapped with Architect, Electrical, Mechanical and Interior Design". *Figure 4.21* shows the links between ICT component and Engineering disciplines.

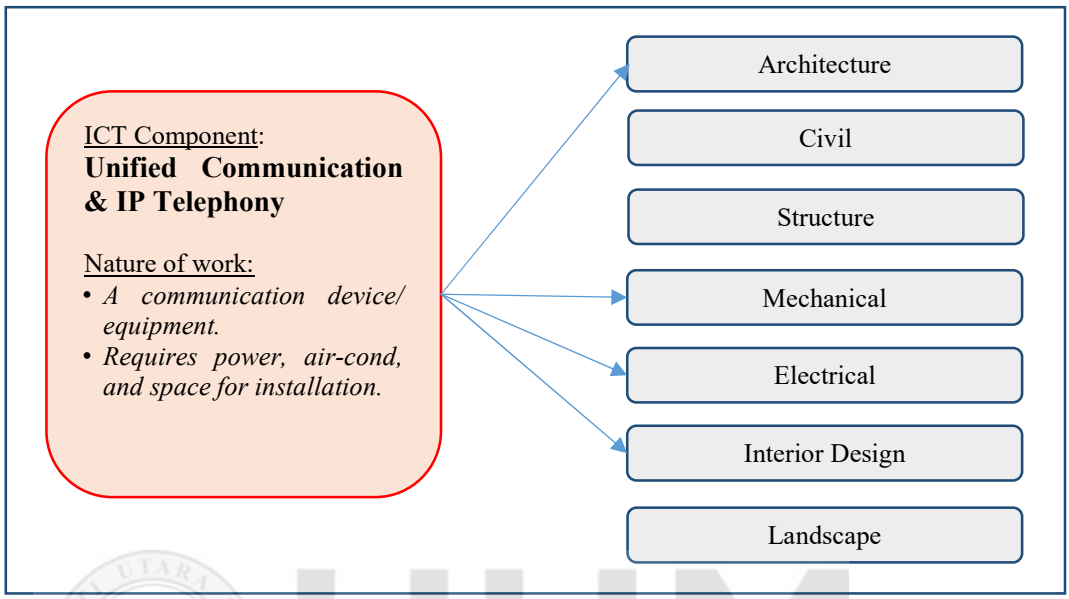

Figure 4.21

Identification of ICT Interface and Mapping – Unified Communication & IP Telephony

A Quantity Surveyor (QS) for ICT works packages was appointed for managing cost and procurement. The infrastructure works which comprised of road, water, electricity, telecommunication, drainage, street lighting etc. did not have architect consultant. There were four (4) levels of decision making for the ICT consultants get decisions on the design work, issues or problems that occur during the design phase of the project. The researcher had compiled and depicted level of decision making as shown in *Figure 5.12* in Chapter 5.

4.5.5 Evaluating Action

Evaluation of action describes the judgement or value to the actions taken by the researcher and the ICT team whether the objective of *AR Cycle 2* was achieved or not. Revision were made during the AR cycle where some of the planned actions were further refined and specified. Iteration of actions were made up as part of the exploration to examine the ICT works interface and engineering works, and to match them in order to get the relationship of the works between ICT and Engineering. Table 4.9 describes the result of AR Cycle 2 and the revision made during the iteration of actions.

Table 4.9
Evaluating Action for AR Cycle 2

No.	Issues	Plan for Action	Result	Revision Made
1.	How to map the ICT works with the Engineering disciplines?	Review ICT Preliminary/Detailed Design. Meeting with the ICT consultants in Focus Group sessions. Special sessions with each ICT Consultant discipline for in-depth discussions. Observe the communication aspects among the project consultants.	The researcher managed to map the ICT works with the engineering disciplines.	Review ICT Preliminary/Detailed Design. Examine the nature of ICT work and categorise the work based on type of Engineering discipline List the attribute of each ICT interface Link ICT Work Packages with Other Work Packages Match the similarity of work between ICT and Engineering Map the ICT work to all relevant Engineering disciplines

Figure 4.22 illustrates process of refined actions as a result of the journey in the AR Cycle 2.

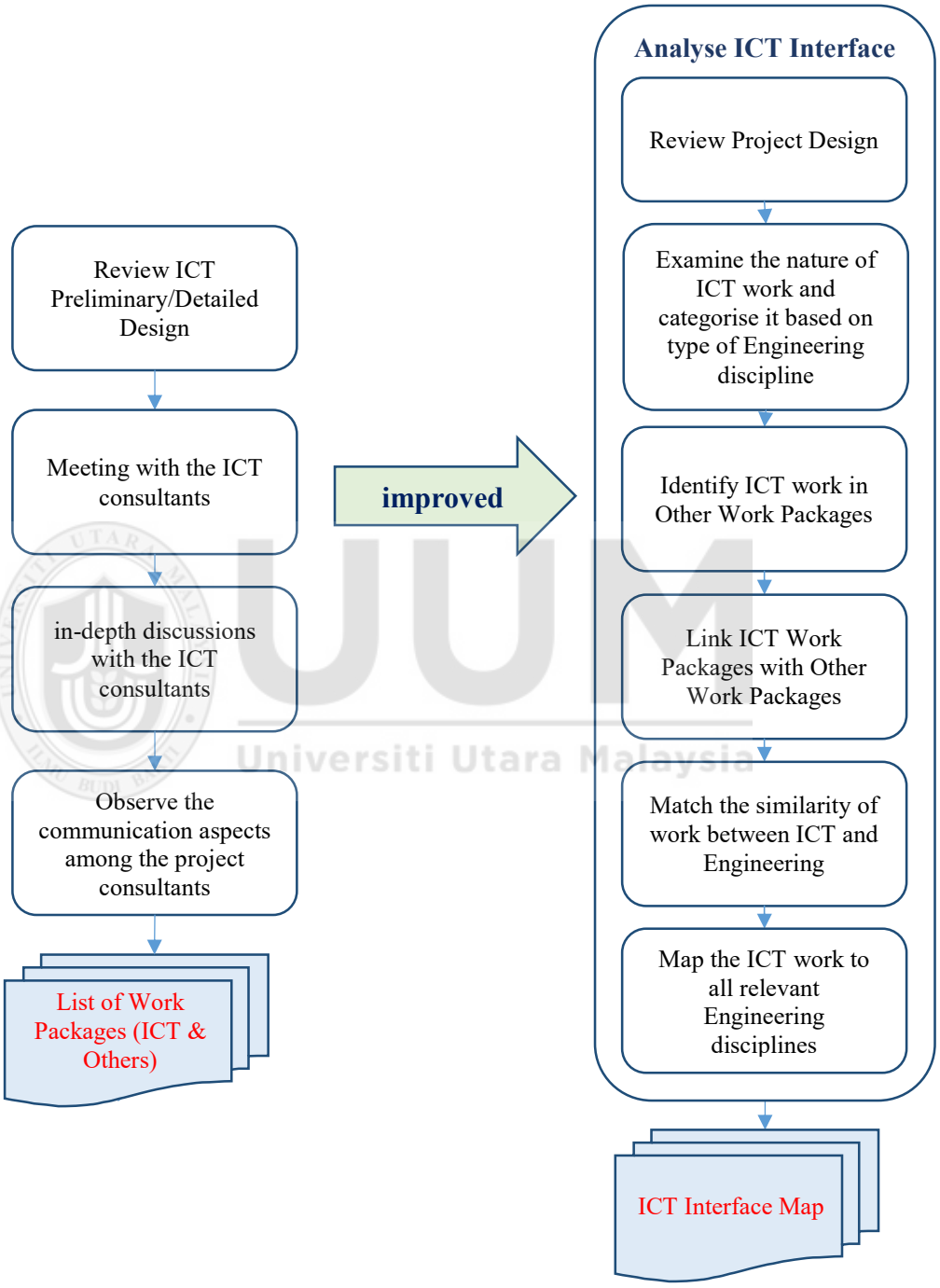

Figure 4.22
Action Revision in AR Cycle 2

4.6 *AR Cycle 3*: To define the ICT Interface Plan & Procedure based on the processes explored in the AR Cycle for the development of the ICT Works Interface Framework

4.6.1 Context and Purpose

The journey in *AR Cycle 3* was focusing on the interface requirements and the process involved in the ICT Work Interfacing. The ultimate goal was to establish the ICT Works Interface Framework based on the process flow developed during the whole *AR Cycles*.

4.6.2 Constructing

The researcher's review found that no framework nor procedure in the project quality management system that could be used by the ICT consultants. This was evidenced by the absence of document in the form of quality records for interfacing works in the project quality procedures.

Therefore, the researcher had proposed an ICT Interface Procedure as an instrument in which all interfacing process flow to be conducted could be referred by the ICT team. In order to achieve the goal set in this context, the major question need to be answered was: "How to plan and coordinate the interfacing works between ICT and Engineering disciplines?"

4.6.3 Planning Action

To tackle the issues highlighted in the previous section, the researcher had proposed and produced a quality record templates i.e. ICT Interface Plan. The template was used by the researcher to execute the *AR Cycle 3*.

Table 4.10 describes the details of ICT Interface Plan to be used by the researcher together with the focus group.

Table 4.10

ICT Interface Plan Template

No.	Template Name	Particular of Data
1.	ICT Interface Plan	Name of ICT Work Package Name of Construction Work Package Name of ICT Component/Equipment Type works to be carried out Scheduled-In Scheduled-Out Location

Table 4.11 describes the plan prepared by the researcher for implementation of *AR Cycle 3.*

Table 4.11

Planning Action for AR Cycle 3

No.	Issues	Data Required	Methods	Plan for Action
1.	How to coordinate the interfacing works between ICT and Engineering disciplines?	Time Geographical/ Location Organisation Technical Responsibility	Observations Document Review Focus Group In-depth Interview	Review Construction Implementation Plan. Design Coordination Meeting with Engineering Focus Group. Observe the communication aspects among the project consultants.

4.6.4 Taking Action

The researcher started with defining the requirements of ICT interface. Five (5) type of interfaces i.e. *time, organisation, technical, geographical* and *responsibility*, had been identified to be explored during *AR Cycle 3* implementation.

a) *Time* – time interface refers to duration and commencement of works.

b) *Organisation* – organisation interface states the multi-discipline parties involved in the project.

c) *Technical* – technical interface describes specifications of materials used in interfacing works.

d) *Geographical* – geographical interface tells the physical location of interfacing works.

e) *Responsibility* – responsibility interface distinguish scope of works to be carried out by interfacing parties. The main objective is to avoid gap or overlapping works in the project.

The interface requirements were then examined and transferred into ICT Interface Plan. Type of construction work package in which the ICT works to be carried out and components to be installed were also being identified and registered.

4.6.5 Evaluating Action

Evaluation of action in *AR Cycle 3* had been successfully implemented and refinement to the planned actions had yielded good results. Starting with the ICT interface registration was a good attempt to set up a central quality record for project team references. Action planning initially was quite common, such as review of implementation plans and also holding interface meetings. There was no specific agenda in the implementation of actions to achieve the objectives set. After going through several meetings and reading on project documents, the researcher had identified who were the stakeholders or consultants who have the roles and responsibilities in ICT-related interfaces.

As a result, Matrix chart of responsibility was produced as a reference instrument. The researcher also produced line of communication for the ICT team so they could plan their activities and getting approvals at several decision-making levels.

Lastly, based on the Matrix Responsibility Chart, structured meetings had been planned and held to determine and coordinate time, location and technical requirements for every ICT work interface. Table 4.11 shows the results and revision made in *AR Cycle 3*. *Figure 4.23* illustrates the main part of the ICT interfacing work process that generates the basic component of the IWIF framework.

Table 4.12
Evaluating Action of AR Cycle 3

No.	Issues	Plan for Action	Result	Revision Made
1.	How to coordinate the interfacing works between ICT and Engineering disciplines?	Review Construction Implementation Plan. Design Coordination Meeting with Engineering Focus Group. Observe the communication aspects among the project consultants.	The researcher managed to define and capture the the ICT interface requirements which cover the *time, location, organisation, technical* and *responsibility* of each ICT work interface.	Register ICT Interface Identify the roles and responsibilities of the consultants and stakeholders involved Build a responsibility matrix chart Prepare Line of Communication for ICT Works Conduct Meeting with Stakeholders / Consultants Define & coordinate *time, location, organisation,* and *technical* for each ICT work.

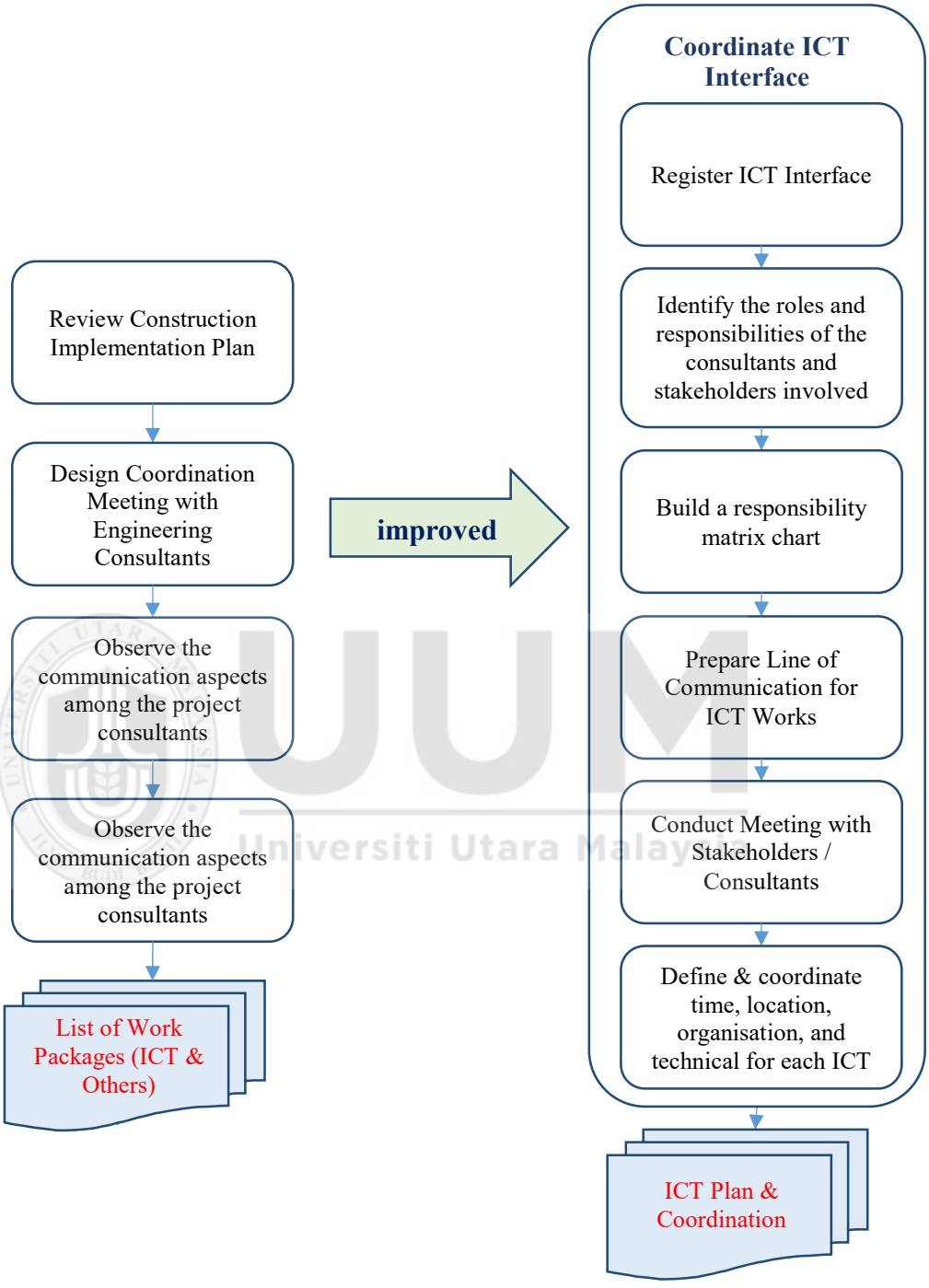

Figure 4.23
Action Revision in AR Cycle 3

4.7 Chapter Summary

The three-year design development of the project resulted in a fruitful collaboration among the project consultants, during which important insights were gained into how the ICT consultants perceived and adopted the construction integrations. Based on the analysis and findings from the life case study, it helped the researcher to adapt ICT works interface framework as a model of interfacing that able to revise interface-ability for ICT works involved in a construction base project. The strength of the proposed framework is it make ease of identification of communication and collaboration point at the early stage prior to physical construction starts. The ICT works interface with multidisciplinary engineering works could be mapped and established during design stage.

In the proposed framework, requirements engineering approach and interface coordination will be included as part of the development of ICT works interface framework. The framework would help in terms of enhancement of Project Quality Management System of a construction company and become part of references for the company to manage ICT works for its entire construction-based project. Hence, it also benefits the government and construction industry at large.

CHAPTER FIVE
PROPOSED FRAMEWORK

5.1 Introduction

This chapter presents the proposed ICT Work Interface Framework (IWIF) based on the analysis of the Action Research conducted. Starts with the rationale behind the development of IWIF, the section then continues with process flow forming up the framework architecture. The detail description of the proposed framework is included in the subsequent sections. The summary of IWIF ends this chapter.

5.2 Overview of Proposed Framework

IWIF is a framework with an approach of interfacing planning and procedure for ICT consultants and contractors involving in large scale construction project. The objective of IWIF is to provide revision of work interfacing between ICT and engineering. The proposed framework is based on the results of AR Cycles implemented during project case study.

There are three major process group wings which are the Interface Identification, Interface Analysis and Interface Plan & Coordination.Each process grouping is described in the Section 5.3, Section 5.4 and Section 5.5 respectively. *Figure 5.1* shows the proposed IWIF Architecture.

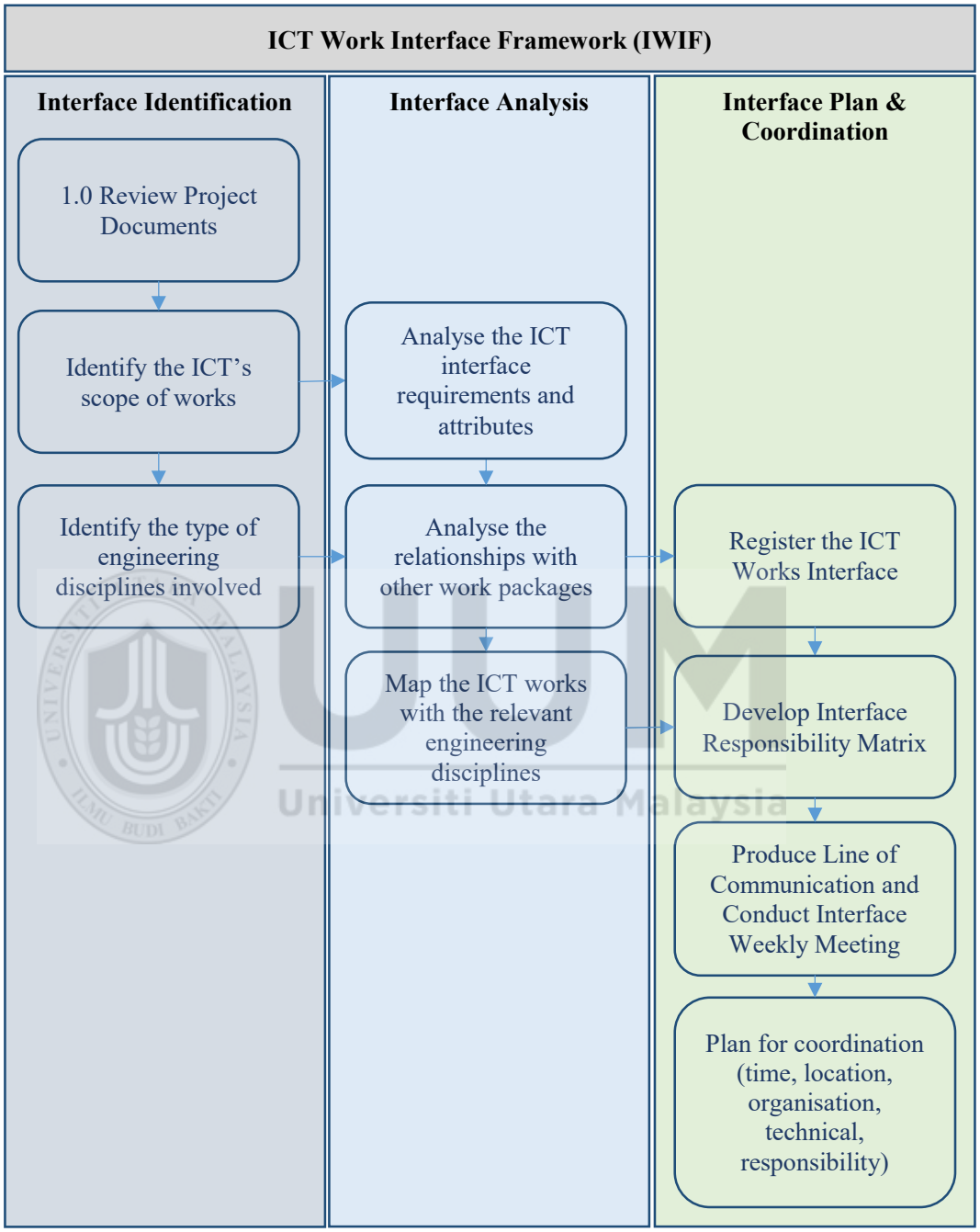

Figure 5.1
ICT Works Interface Framework (IWIF) synthesised by the researcher based on the resolution and revision made during Action Research Cycle

5.3 Interface Identification

Interface Identification group includes process activities for the identification and collection of data which will be used in the subsequent process activities. The Interface Identification consists of three (3) major processes: 1) review project documents; 2) identify the ICT works involved; 3) identify the type of Engineering disciplines involved. The output of this group are:

1. Project Review Form
2. List of ICT works
3. List of Engineering disciplines

5.3.1 Review Project Documents

The first step in IWIF is to review project documents. The main objective is to understand about the project, its goals, deliverables, project timeline and stakeholders involved.

The first project document that the ICT team should review is the Client's Requirements. The Client's Requirements might be in the form of Scope Book or Needs Statements or Project Brief, subject to the term used by the project owner or project developer. Next, the ICT team should get and review the project Master Implementation Plan.

Table 5.1 list the common relevant documents to be gathered by the ICT team in the early stage of the project.

Table 5.1
Project Documents

No.	Document Name	Document Description
1.	Client's Requirements: - *Scope Book* or - *Needs Statement* or - *Project Brief*.	This document states the client's requirements and the scope of works to be delivered by contractors.
2.	Master Implementation Plan	This document describes the project programs and activities to be carried out by the developer/contractor to achieve the project goals.

Typically, these kind of documents are available and should be made available within a month by the appointed developer or contractor. There are also cases where the preparation of those documents takes up to six (6) months. Meaning that, by the time the ICT Consultant enter to the project, they should have been furnished with the project information.

In most large scale construction project, there is a unit called Document Control under the Project Administration. Usually, those documents can be easily discovered and accessed from this Document Control Unit.

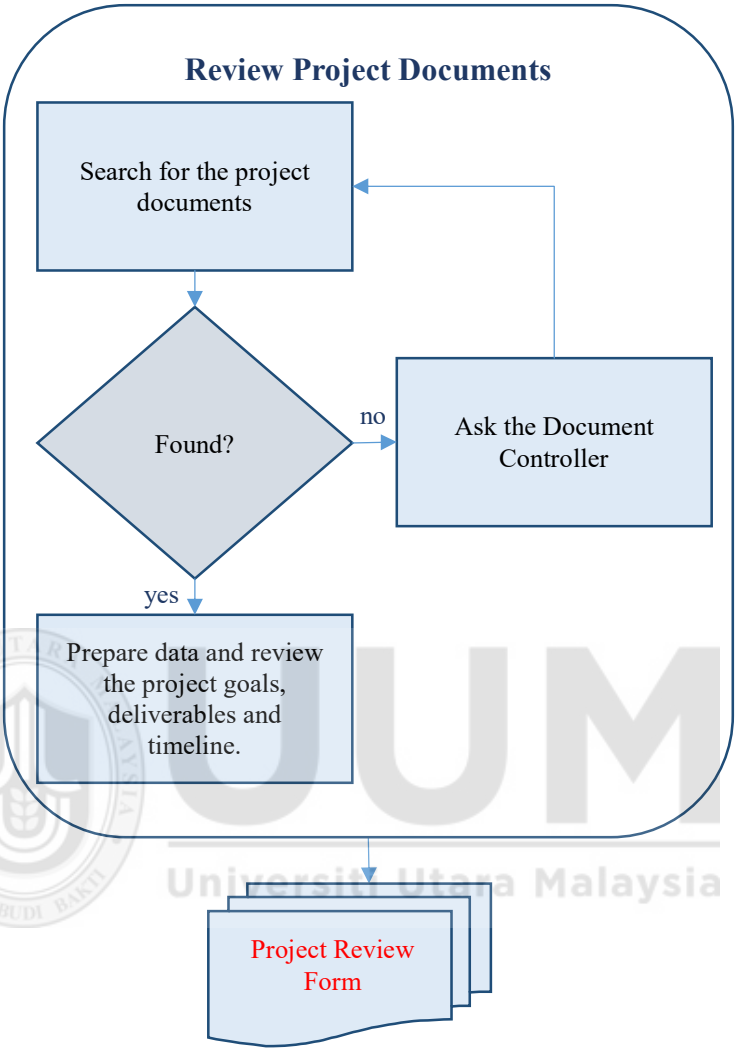

Figure 5.2
IWIF Framework :Flow of Review Project Documents

Figure 5.2 depicts the flow of Project Document Review starting from the searching documents till recording relevant information into Project Review Form. If the relevant project documents are not found, the ICT Consultants should request them from the Document Controller. Once

obtained, the preparation and extraction of relevant information will then be executed. The major data such as project goals, deliverables, timeline, and stakeholders involved will be captured. In this proposed framework, Project Review Form is used as a tools for recording the data captured. Example of Project Review Form is shown in Appendix.

5.3.2 Identify the ICT works involved

Identifying the ICT works is part of the review project documents where the main objective is to capture and list the type of ICT works and trade involved in the project. It starts with identifying the type of ICT trade involved in the project based on facts stated in the project documents reviewed. For each of trade identified, its scope of work will be captured. The output of this process is the List of ICT Trades & Scope of Works. *Figure 5.3* depicts the process of Identification of ICT Works.

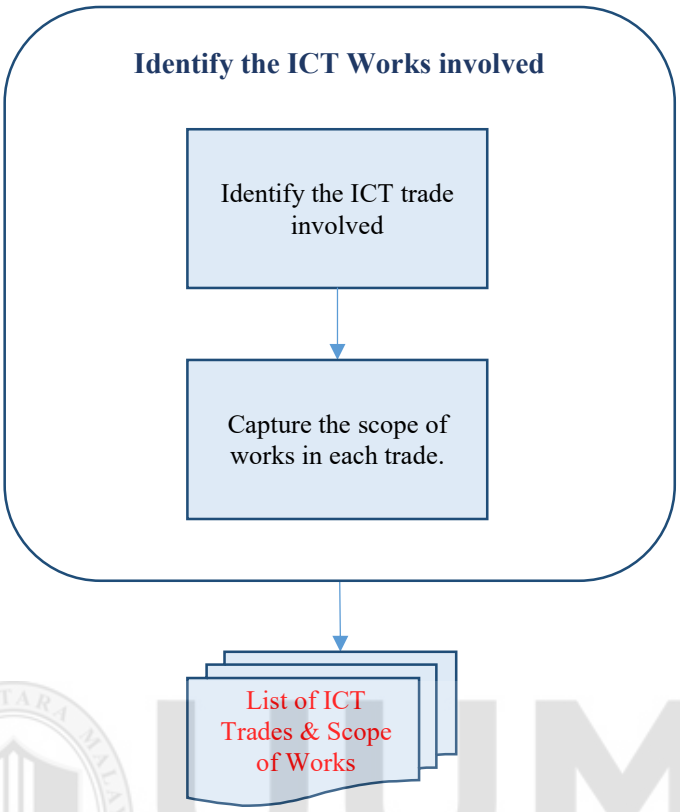

Figure 5.3
IWIF Framework : Identify the ICT Works involved

5.3.3 Identify the type of engineering disciplines involved

Figure 5.4 depicts the process of Identification of Engineering Discipline. The main objective of this process is to capture and list the type of engineering discipline involved in the project. It starts with identifying the construction's scope of works involved in the project based on the project documents reviewed. For each of construction work, the type of engineering discipline involved will be captured and recorded in the List of Engineering Disciplines.

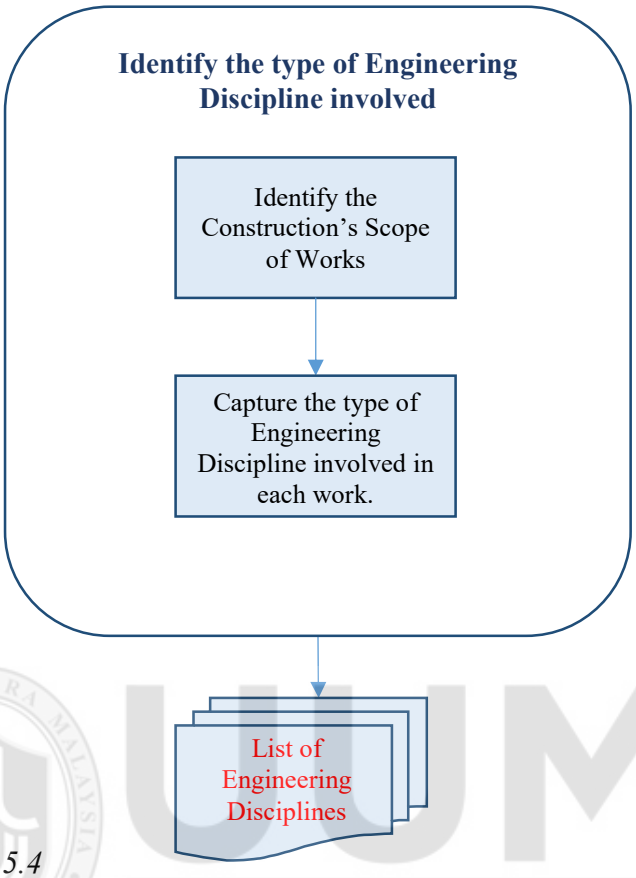

Figure 5.4
IWIF Framework : Identify the type of Engineering Discipline involved

5.4 Interface Analysis

Interface Analysis is the next process groupings after Interface Identification. This group consists of two (2) processes: 1) Analyse the ICT interface requirements and attributes; 2) Map the ICT works with the relevant engineering disciplines. At the end of this process, the followings should be established:

1. ICT works interface requirements.
2. ICT works interface mapping.

5.4.1 Analyse the ICT interface requirements and attributes

In the previous process, selected project documents are read and reviewed to find out the scope of work for ICT and the scope of work for construction involved in the project. The purpose is to identify what types of ICT Works Interface contained in the scope of ICT works involving engineering work in the construction project.

Next, for each ICT Work package identified, analysis of its interface will be carried out. The objective is to examine the nature of work contained in the ICT Work Package and also to identify the attributes for each of the works. *Figure 5.5*illustrated the sub-processes involved in the interface analysis. The first process is to examine the nature of each ICT work and categorise it based on type of Engineering discipline.

For example, a Network Infrastructure Work Package has two common civil works which are trenching and ducting. It has become commonplace in any construction contract works that trenching and ducting works are part of infrastructure work. The nature of these works require civil engineering works. Therefore, the trenching and ducting works can be categorised under civil engineering disciplines.

The second process is to list the interface attributes for each work of ICT Work Package. For example, how many and what size of ducts are required for the ducting work under Network Infrastructure Work package.

In this requirement, number and size are among the attributes of ducting work in the Network Infrastructure Work Package. All these information shall then be recorded and logged into an Interface Requirement Form (IRF).

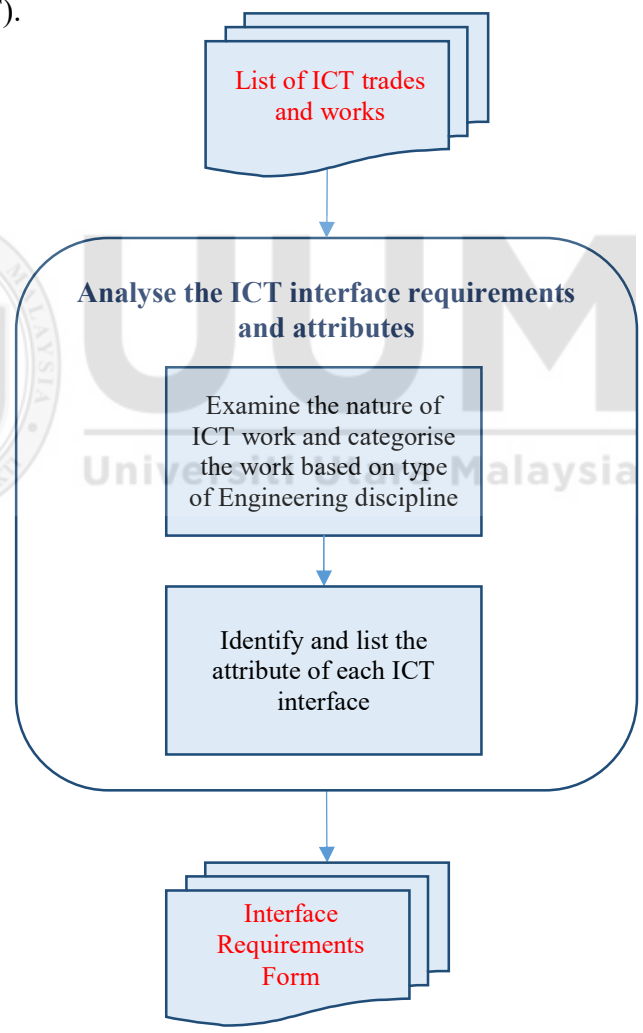

Figure 5.5
IWIF Framework : Analyse the ICT Interface requirements and attributes

5.4.2 Analyse the relationship with other work packages

Interface Requirements Form which is the output from the previous process is used as input to this process to identify the ICT works in other work packages. The ICT work packages are then to be mapped with other construction work packages to confirm the linkage of interfacing works as shown in *Figure 5.6*.

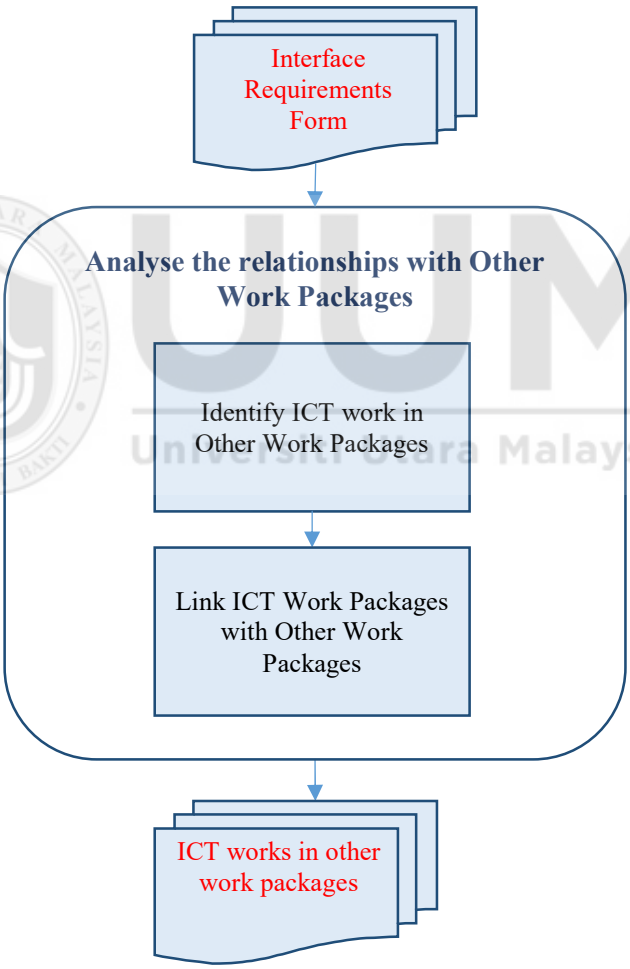

Figure 5.6
IWIF Framework : Analyse the relationships with other work packages

Table 5.2 shows the sample of matrix of interfacing works between ICT Work Packages and Construction Work Packages. It shows that ICTWPC1 and ICTWPC3 have interfacing works with all Construction Works Packages of the project.

Table 5.2
Matrix of Interfacing works between ICT Works Packages and other Construction Works Packages

ICT Works Package	**Construction Works Packages**					
	Building WPC1	Building WPC2	Building WPC3	Building WPC4	Building WPC5	Infra Works WPC6
ICT WPC 1: Network Infrastructure	√	√	√	√	√	√
ICT WPC 2 : Data Centre		√				
ICT WPC 3 : Security System	√	√	√	√	√	√
ICT WPC N :						

5.4.3 Map the ICT works with relevant engineering disciplines

After the attributes and the requirements of the interface have been identified and recorded, the matching process is then performed. Every ICT work that has been defined its attributes and requirements will be matched with the engineering work in accordance with the engineering discipline.

Table 5.3
Matching the ICT works with Engineering disciplines

ICT Works Package	**Engineering Disciplines**						
	Arch	Civil	Struc	Mech	Elect	I.D.	Landscape
ICT WPC 1: Network Infrastructure	√	√	√	√	√	√	√
ICT WPC 2 : Data Centre	√	√	√	√	√	√	
ICT WPC 3 : Security System	√	√	√	√	√	√	
ICT WPC N :							

Table 5.3 shows how the ICT Work Packages been matched with Engineering Disciplines. For example, Network Infrastructure which is the ICT Work Package 1 is matched with Architecture, Civil, Electrical, I.D., and Landscape. The matching is based on the similarity of nature of works from both ICT and Engineering.

Figure 5.7 illustrates the mapping of Network Infrastructure works with the relevant Engineering Disciplines.

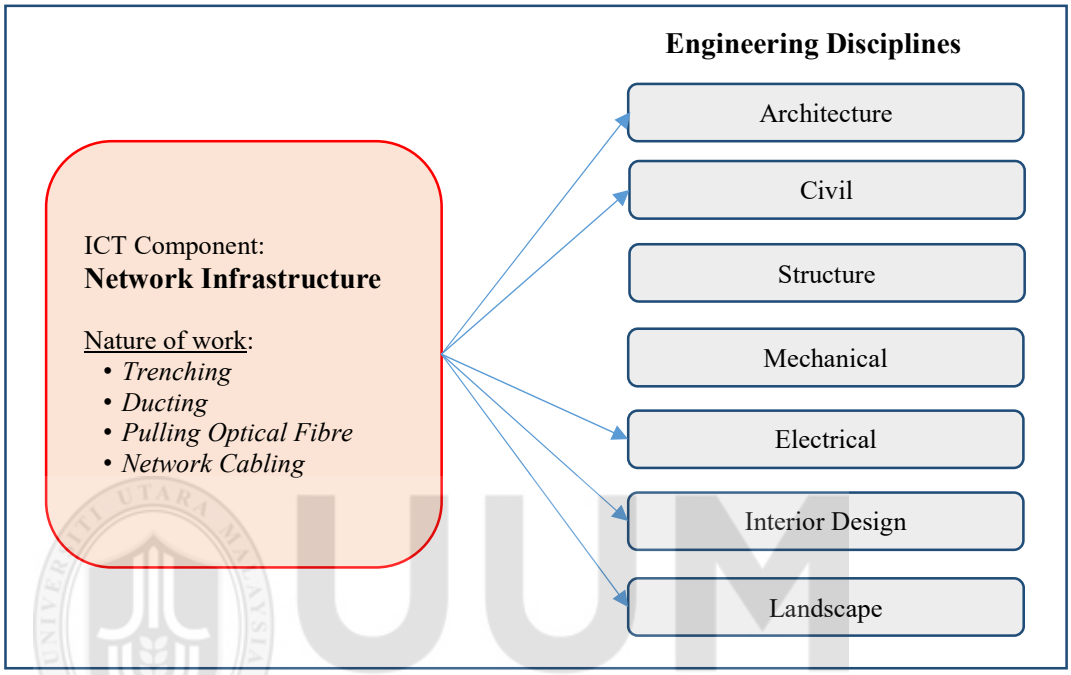

Figure 5.7
Mapping the ICT Component with the matching Engineering Disciplines

Figure 5.8 illustrated the summary of processes involved which are form part of IWIF. The process starts with matching the similarity of work between ICT and Engineering involved in the project. The ICT works then be mapped with the relevant engineering disciplines. The outcome from these processes are very crucial because any missing item or incomplete data gained will affect the coordination plan. Consequently, it will affect the ICT interfacing works in the construction project.

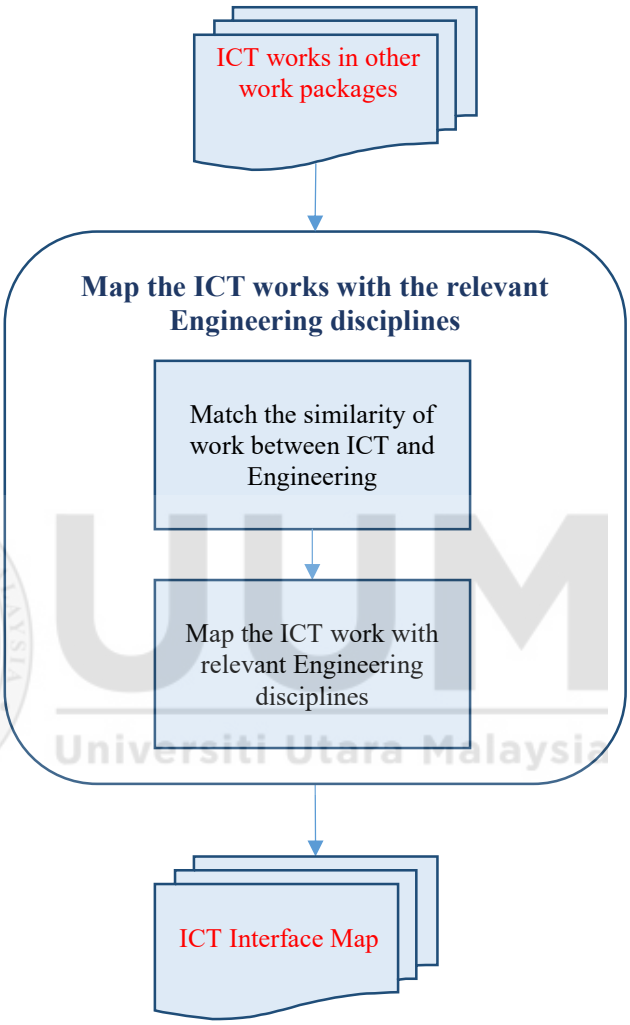

Figure 5.8
IWIF Framework : Map the ICT Works with the relevant Engineering Disciplines

5.5 Interface Plan & Coordination

The ICT team shall produce project communication line including meeting matrix for ICT project team. This is to show the coordination of works and the level of changes as well as decision making in the project. Interface plan and coordination are activities that involve collaboration with stakeholders as well as other project consultants. It is a structured communication that is to coordinate the work of the interfaces from related engineering disciplines involved. The main purpose is to achieve a collaborative agreement and decision to deliver the required functionality in project integration. The expected outputs of this groupings are:

1. ICT Interface Register
2. ICT Interface Responsibility Matrix
3. ICT Interface Line of Communication
4. ICT Interface Control Document

5.5.1 Register ICT Works Interface

Registration of ICT Works Interface is the process where the ICT team to prepare the instruments for quality record which is ICT Interface Form. The form is used for logging all the identified ICT interfaces' requirements and attributes.

This is part of quality record activities where the information can now be shared by the relevant parties for further discussions and/or actions. *Figure 5.9* illustrated the preparation of ICT Interface Registry where the inputs are obtained from the ICT Interface Requirements and ICT Interface Mapping.

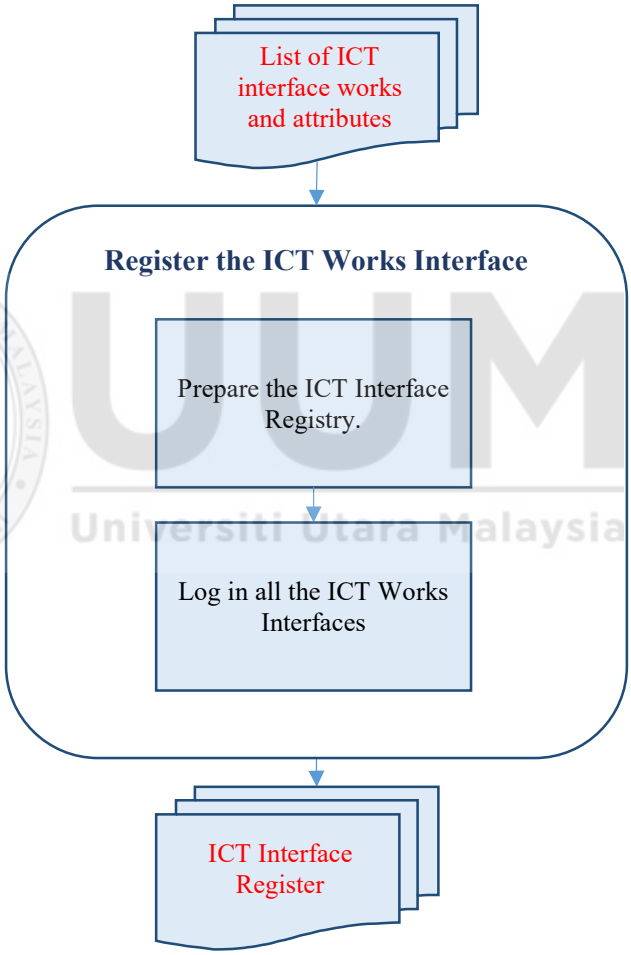

Figure 5.9
IWIF Framework : Register the ICT Works Interface

5.5.2 Develop Interface Responsibility Matrix

Interface Responsibility Matrix is a responsibility chart describes the responsible ICT Consultants by various ICT disciplines versus the stakeholders and/or parties involved in completing ICT interface tasks for an ICT Work Package. *Figure 5.10* illustrates the processes involve in the development of ICT Interface Responsibility Matrix.

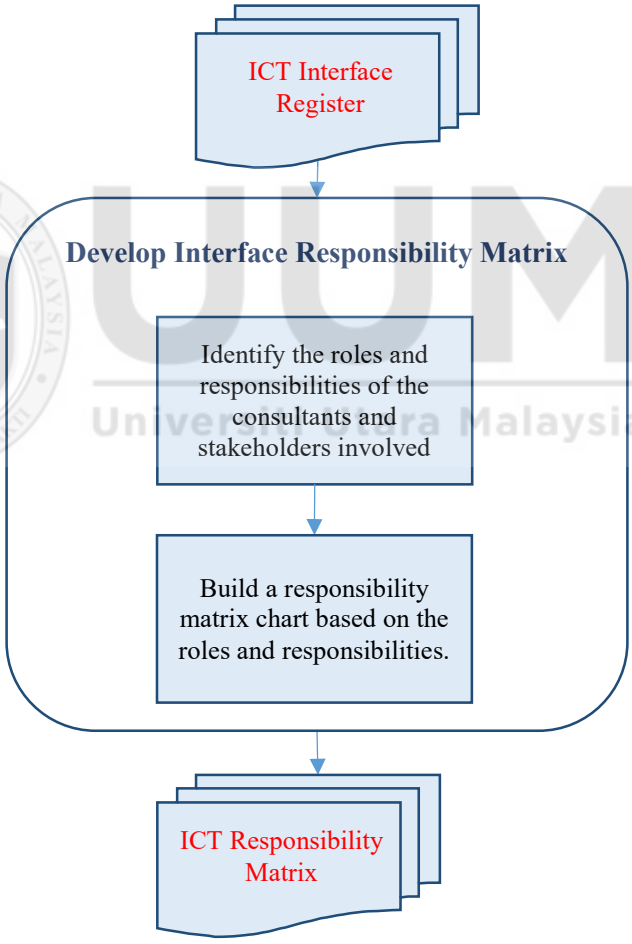

Figure 5.10
IWIF Framework : Develop Interface Responsibility Matrix

Table 5.4 shows examples of tasks and the responsibilities of ICT consultants cross-sectioning stakeholders and engineering consultants in managing the ICT Interface works. It shows that every ICT task has minimum of three (3) interfaces with other stakeholders or consultants involved in the project.

Table 5.4
ICT Interface Responsibility Matrix

Item	ICT Interface Tasks	Stakeholders / Consultants							
		Architect	Civil Engineer	Structural Engineer	Mechanical Engineer	Electrical Engineer	Interior Designer	Landscape Architect	Network Engineer
1.	**Network Infrastructure Work Package**								
1.1	Trenching		√					√	√
1.2	Ducting		√					√	√
1.3	Pulling Optical Fibre (outdoor)		√					√	√
1.4	Data Cabling (indoor)	√					√		√
1.5	Communication Room Lighting airconditioning power security	√			√	√			√
2.	**Data Centre**	√	√	√	√	√	√		√

5.5.3 Conduct Interface Meeting (Interface Communication)

An interface meeting can be called if we know who are the responsible persons involve in a project. Therefore, in order to make sure the right persons attend the meeting, the ICT team should know the level of decision making in a project. A line of communication for ICT Works shall be established and distributed to all ICT team members.

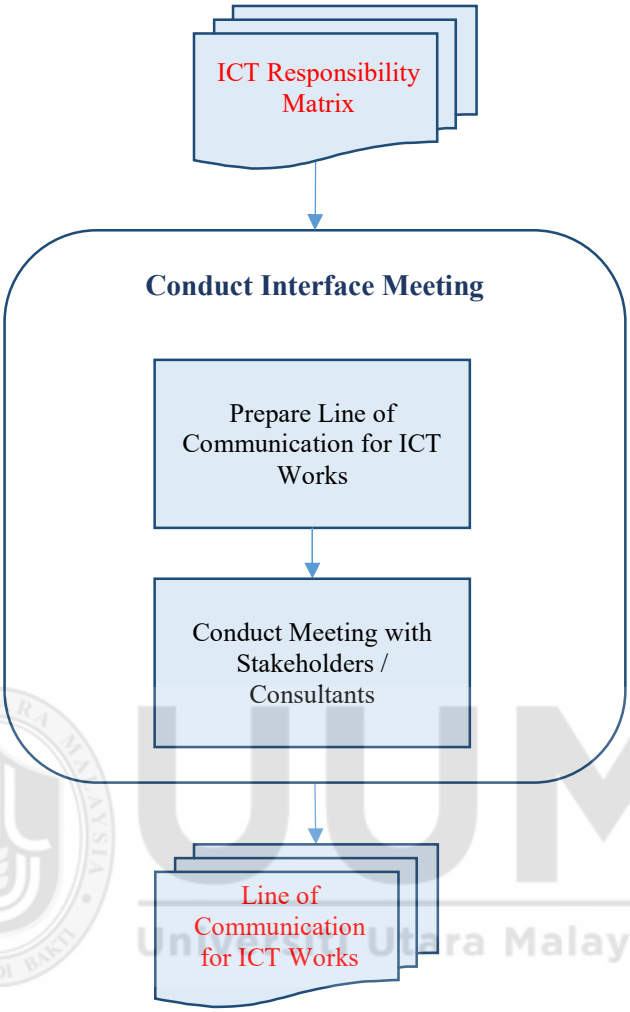

Figure 5.11
IWIF Framework : Conduct Interface Meeting

Figure 5.11 illustrates the processes involve in the IWIF for conducting Interface Meetings. It starts with preparation of line of communication for ICT Works involved in the project. *Figure 5.12* illustrates sample of Line of Communication for the ICT Works showing level of decision making involve in the LGM project. Next, the ICT team will has to attend all the meetings set and agreed by the project management.

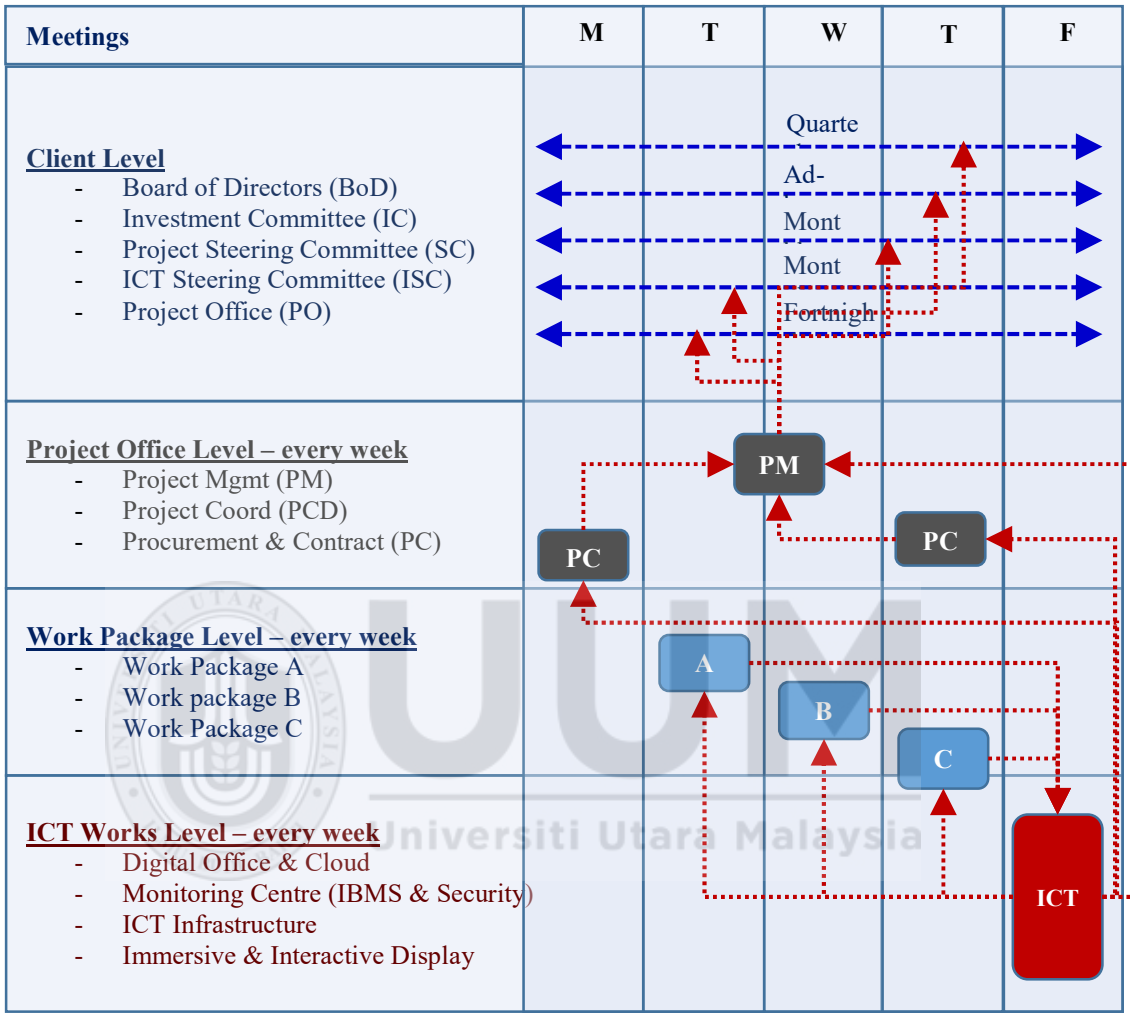

Figure 5.12
ICT Line of Communications and Level of Decision Making

5.5.4 Plan for coordination (time, location, technical, responsibility, organisation)

After doing the interface identification and analysis on its requirements and relationship with the construction works, the next step is to coordinate the interfacing works.

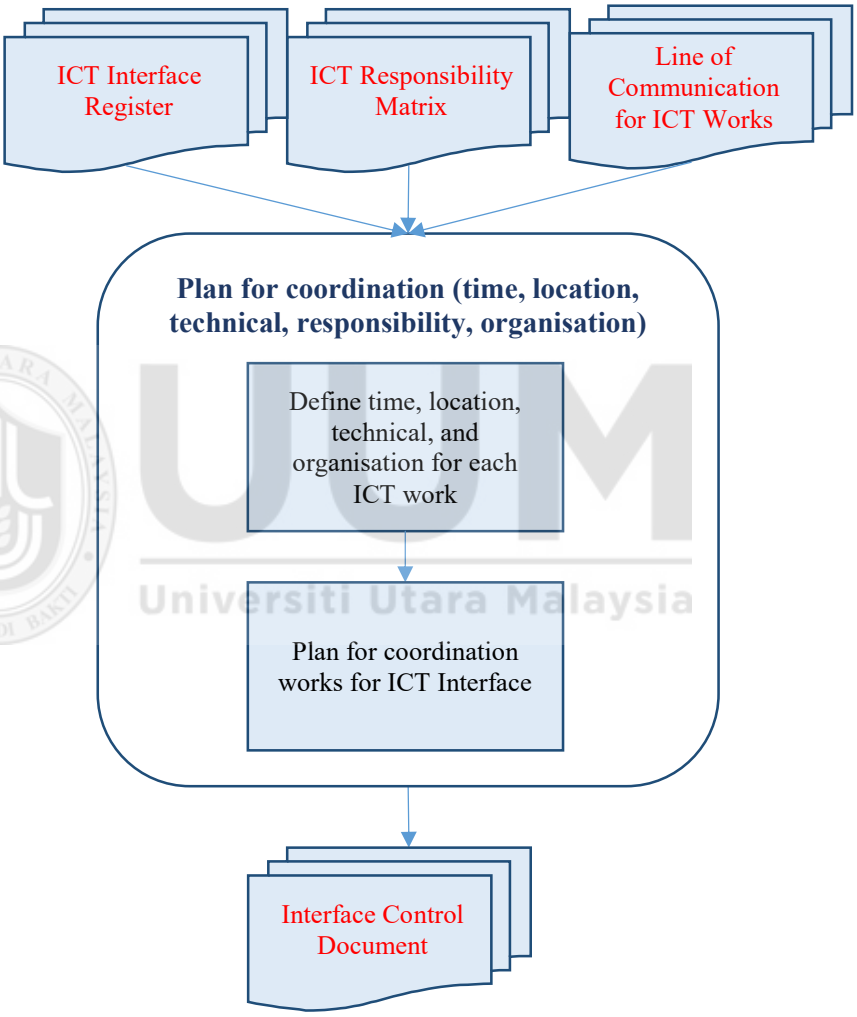

Figure 5.13
IWIF Framework : Plan for coordination (time, location, technical, responsibility, organisation)

In this IWIF Framework, Interface Coordination means putting the interfacing works at the right time, at the right location, with the right technical materials/tools/specifications, with the sufficient scope of responsibility, to the right organisation/party/person. *Figure 5.13* illustrated the processes of Plan for Coordination involving time, location, technical, responsibility and organisation.

In construction project, timing is the most critical for the interfacing works as it involves several parties to coordinate the works. Delay of works by one party will affect works from other parties. And this will give impact to the overall project timeline. Therefore, the ICT team has to know when is the right time to commence their works in line with related engineering works within certain period during construction development.

For example, Data Cabling work can start on the same date with electrical wiring works due to similarity of their nature of work and interfacing requirements. *Figure 5.14* illustrated the Date In and Date Out for the Data Cabling work during building construction works.

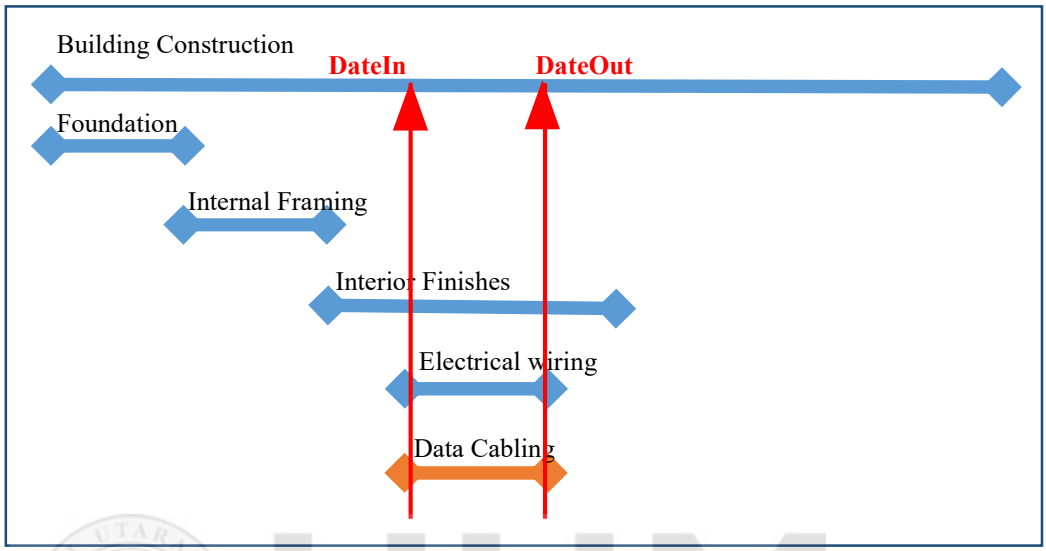

Figure 5.14
ICT Interfacing : Date In and Date out for ICT works

Coordination of location can only start after the location of an ICT service has been set. For example, once the location of a CCTV camera is identified and confirmed then its requirement must be fulfilled such as PowerPoint. This indirectly has made known to the ICT team that electrical works should be coordinated for the interfacing works to achieve the CCTV functional objectives. Coordination of technical will determine what is the appropriate mounting bracket suite for the CCTV camera, what material and method required for the camera installation. All these are depending on the physical area of the location.

Coordination of responsibility represents the scope of tasks to be carried out by the ICT team and other parties based on the coordinated location and technical identified. Coordination of organisation links the ICT team with the right parties involve in the interfacing works.

5.6 Chapter Summary

The strength of the proposed framework is it revises the interfacing process between ICT and Engineering works. More ICT components with multi-disciplines can apply the framework, as such, providing high efficiency and interface constructability for construction works interfacing. Three major process groupings are the basis of the ICT Works Interface Framework.

IWIF shall become the main reference and guidance to ICT Consultants as well as to facilitate ICT Contractors to perform ICT works interface with ease and effective. Consequently, it will benefits construction industry both project owner and developer.

CHAPTER SIX
DISCUSSION CONCLUSIONS

6.1 Introduction

This chapter presents the conclusions and recommendations for further research. The chapter summarize all the activities involve during Action Research. Next, research contributions and limitations are discussed followed by recommendation for further works.

6.2 Recapitalisation of Research Objectives

The research aim is to develop ICT Works Interface Framework as a reference that make ease of ICT works integration efforts to ICT consultants and contractors involving in construction project by proposing a new ICT work interface framework. Based on the researcher's participation in few government's mega project in Malaysia especially in the project case study, it shows that ICT framework is very important for the ICT consultants and contractors to understand the nature of construction environment.

Interfacing instruments for ICT works are the most important element for information sharing with other parties from various engineering disciplines involve in the project. Level of constructability of an interface is very much depending on the successful of interface design in order to support the overall ICT functional. The development of framework requires a universal way which should always applicable in practice. Since most ICT works in construction have a

common set of criteria and requirements with other engineering disciplines, the interface-ability seems to be easy to achieve and it should not be an issue.

As the success of interface-ability to be so important for the ICT works in construction, this research has focused on the ICT work interface framework. A life case study was chosen after a preliminary study was done. Initial study was to probe the problems on the ICT Works in a construction project as well as its interface-ability with other construction's disciplines. Meanwhile, literature review on the Interface Management (IM) was also carried out to know the IM approaches as discussed in Chapter 2. Other related works regarding the ICT works in construction projects were also highlighted.

In Chapter 3, the research methodology explains the research design, defines the framework of interface, and describes method of case study which has been carried out to explore the problems of ICT works in a construction project. After the problem formulation established, investigation on the Interface works to the case study began where technical documents reviews, focus group, observations, and interviews had been conducted as per research framework. All these are depicted in the research methodology chapter. Based on the case study conducted, the researcher found that some of the ICT work have similar in term of type of engineering discipline with other construction works. For example, ICT cabling works have similarity with wring works in electrical. Their interfacing works with other engineering disciplines such as Architect and Interior Design are almost same.

In Chapter 4, the exploratory study and analysis on the ICT works interface shows every ICT work has its own interface requirements which should be defined and matched with type of engineering disciplines in the construction. The complexity of the interface increases and become unmanageable when the number of different ICT works with different type of interfaces involved increased. Level of interface-ability was very low and required for improvement of interface definition and design. Therefore, IWIF was proposed to provide framework for interface definition and design of the ICT works. The main purpose of the IWIF is to overcome the issue of interface definition where the complexity of the interfacing process can be dissolved and make it simpler. Chapter 5 describes the selected and accepted processes forming up the overall framework of ICT works in the case study. No validation is required to the framework since it was tested and proven during the project implementation.

As a conclusion, this research is very successful because it has succeeded in producing a proven framework solving the interfacing problem between ICT and engineering works involved in a large scale construction-based project. The framework has proved beneficial to those involved in the interfacing works of the construction project managed by KLIACS. Based on the case studies conducted, the functions, features, components involved and methods used in ICT works interfacing were captured to understand more about the interface requirements. The study is deemed important for proper recognition of improvement in the management of construction interfacing involving ICT works which is consider a

new trade in construction project. Likewise, the findings of this research is able prove useful to the followings:

1. ICT Contractors – The study has given a clearer view and better understanding of construction works. This will further enhance the contractors' knowledge about the importance of understanding the multi-trade interfaces so they will make an effort to do best. This possibly will lead to better delivery process and develop good work practice.

2. Project Consultants – This study has increased their awareness in identifying the ICT tasks which are now becoming part of engineering trades. This has further be a key factor to adapt methods and new strategies for the revision of construction interfacing involving ICT works.

3. Project Owner or Developer – The result of this study will serve as bird's eye view of the project owner or developer to know the needs of ICT works interface with regards to improving their project management in construction industry.

4. Academician – The findings of this research help curriculum planners in the selection of strategies, techniques, and methods that should be reinforced for their curriculum module especially in project management.

5. Researcher Himself – This possibly will serve as inspiration in managing ICT works towards better delivery in term of time, quality of works and cost to a project undertaken.

6. Future Researcher – The information and insights gained from this study would possibly be used as guide for other researcher for better revision of this framework as well as encourage them to conduct lateral studies within their area of preferences.

This research provides a significant contribution to the construction industry as it serves as a guide for companies or government agencies to manage ICT works involving various parties for their entire construction-based project. The research would enable those in large scale construction-based project to establish a practical interface procedure as part of their project integration instrument. The research would also help the academician involved with field management to adopt the framework as theoretical model to be as part of their curriculum module.

6.3 Limitation and Future Works

Based on the limitations discussed in the previous section, it is recommended that the IWIF be extended and expanded to the construction phase so that the framework becomes complete as it covers the overall design and construction phase. Future research will develop it to include other categories of interfaces from functional, organizational/contractual, to resource interfaces. Several of further works recommended are as follows:

a) Control and monitoring points at design milestones should be established to ensure ICT interfacing designs are fully aligned with the overall design requirements.

b) IWIF should have some representation at Board level to revise ICT interfacing across a business, supported by the promotion of the Project Interface Manager in the Project Management hierarchy.

c) Design performance monitoring should be undertaken to ensure that the ICT interfacing at design phase is effective, efficient and productive.

d) The whole project team and client should be involved in IWIF Training and the definition of IWIF processes, which should be presented in a ICT Project Interfacing Plan.

e) Commercial, procurement and construction processes should be aligned with the IWIF to deliver an effective and efficient ICT project.

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APENDIX A: Document Review Form

DOCUMENT REVIEW FORM

SECTION 1

Review Form No.:	Package:	Date of Review: Period Ending :
Doc. Ref./Title :	Contractor/Consultant:	

SECTION 2 : FINDINGS & COMMENTS

No.	Type of Data	Theme

SECTION 3 : REVIEWED BY ICT CONSULTANT/CONTRACTOR

Signature : Name : Date:

APENDIX B: Focus Group Form

FOCUS GROUP FORM

SECTION 1: GENERAL INFORMATION	
Agenda:	Date of Discussion: Time of Discussion: Venue of Discussion:
Objective of Discussion:	

SECTION 2: PARTICIPANTS' INFORMATION	
Name	Position
1. 2. 3. 4. 5. 6. 7.	1. 2. 3. 4. 5. 6. 7.

SECTION 3 : SEMI-STRUCTURED QUESTIONS		
List of Issues	Impacts	Resolutions

SECTION 4 : CHAIRED BY ICT CONSULTANT/CONTRACTOR		
Signature :	Name :	Date:

APENDIX C: Interview Form

INTERVIEW FORM

SECTION 1: GENERAL INFORMATION	
Topic/Issue:	Date of Interview: Time of Interview:
Purpose of Interview:	

SECTION 2: PERSONAL INFORMATION	
Interviewee Name:	Position:
Company Name:	Contact Phone No.:

SECTION 3 : SEMI-STRUCTURED QUESTIONS	
List of Questionnaires	Interviewee's Response

SECTION 4 : INTERVIEWED BY ICT CONSULTANT/CONTRACTOR		
Signature :	Name :	Date:

APENDIX D: Observation Form

OBSERVATION FORM

SECTION 1 : OBSERVATION INFORMATION		
Observation Form No.:	**Package:**	**Date of Observation:** **Time of Observation:**
Purpose of Observation: ☐ Document Verification ☐ Focus Group Verification ☐ Interview Verification ☐ Meeting/Discussion Verification	**Reference of Documents:**	**Status:**

SECTION 2 : DESCRIPTION OF WORK & OBSERVATIONS		
No.	**Description of Work/ Findings**	**Comment/Verification**

SECTION 3 : OBSERVED BY ICT CONSULTANT/CONTRACTOR		
Signature :	Name :	Date:

APENDIX E: ICT Interface Register

ICT INTERFACE REGISTER						
No.	Interface Relation		Type of Works	Date In	Due Date	Remark / Status
	ICT Package	Other Package				
1.						
2.						
3.						
4.						
5.						
6.						

APENDIX F: Semi-Structured Questionnaires

Semi Structured Questionnaires (Inquiry Checklist)

The objective of this questionnaire is to gain information about the ICT Works Interface in a large scale construction-based project. It was prepared as guide with an inquiry checklist to facilitate the researcher to conduct observations, focus group meetings, interviews, and make observation effectively, efficiently and systematic during Action Research in the project case study.

1. What type of construction/project?.
2. What is the project's scope of work?
3. What are the relevant project document to be reviewed?
4. What are the issues of ICT work interfaces in a construction project?
5. How to identify the ICT Works?
6. What are the common engineering disciplines involve?
7. How to relate the works between ICT and Engineering?
8. What are the interface requirements? How to capture interface the requirements?
9. How to plan and coordinate the Interfacing works? Is there any guildeline or framework used for the ICT Interfacing?

APENDIX G: Interview Protocol

Focus Group Interview Protocol

Consulting Firm: _____

Interviewee (Title and Name): _____

Interviewer: _____

Engineering Discipline:

☐ A: Architect
☐ B: Civil
☐ C: Structure
☐ D: Electrical
☐ E: Mechanical
☐ F: Interior Design
☐ G: Landscape
☐ H: ICT

Issues& Impacts Discussed:_____

_____

Resolutions Obtained: _____

_____

_____

Post Interview Comments or Leads:

_____

ICT Works Interface Interviews

Introductory Protocol

To facilitate our note-taking, we will use interview form to record our discussion today. Please sign the form at the end of discussion. Thank you for your agreeing to participate.

Introduction

You have been called to discuss with us today because you have been identified as someone who has a great deal to share about interfacing requirements that relate to your field pertaining to this project. The main focus is on the improvement of ICT Works Interface in construction project, with particular interest in understanding how your engineering field can be planned and coordinated with the ICT works. We can begin to share about the interface objectives, scopes and requirements..

A. Interviewee Background

1. How long have you been in your present position?
2. How long have you been at this consulting firm?
3. Interesting background information on interviewee:
    - What is your highest education level?
    - What is your field of study?

B. Scope of Work and Identification of Interface Type

1. Briefly describe your scope of work in this project.
2. What type of interfacing work does your engineering trade involve in this project?
3. What are the interfaces involved with the ICT works?

C. Identification of Interface Issues/Problems

1. What are the interface problems or issues faced by you in this project especially those involving ICT works?
2. How do you identify those problems?
3. How the problems affect your work?

D. Identification of Interface Requirements

1. How do you know about the interface requirements that involve you with ICT work?
2. What are the interface requirements between ICT and your engineering trade?

E. Interface Plan and Coordination

1. What is your strategy to solve those problems?
2. How do you communicate with the ICT team involved in this project?
3. How do you coordinate the interfacing works?