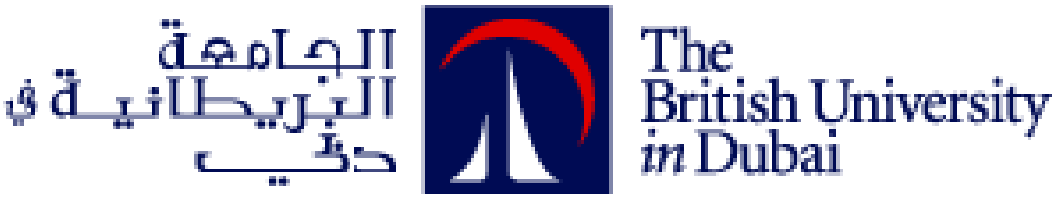

Design Process and Stakeholder Management in Airport Construction

إدارة عملية التصميم وأصحاب المصالح في بناء المطارات

BY

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Dissertation submitted in partial fulfillment of

MSc Project Management

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May-2011

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Abstract

This research explores the challenges associated with managing the design process in complex construction projects. The study focuses particularly on large airport projects, with their inherent complex stakeholder management to be addressed during the design phase. The aim is to propose a framework that integrates Design Process and Stakeholder Management in the context of Airport construction.

The methodology adopted revolves around Modelling and Case Study techniques, to observe and analyse the existing situation and define the model's variables. This approach involves an extensive review of design documents, organizational arrangements, communication between the different involved parties, and interviews with key personnel and stakeholders involved in the design process of airport projects.

In order to develop such a model, an in-depth analysis of the processes and design approach currently employed at a Construction Authority (CA) department in the UAE which is handling the largest airport development in the Middle East, the case studies available provide an excellent framework for this research.

Having analyzed recognized design management frameworks, the Process Protocol Model is adopted albeit with necessary modifications to address the research objectives. The validated and enhanced model shows a powerful tool for the design manager to administer and archive the information flow in airport projects, while defining a framework for managing the stakeholders' requirements.

In conclusion, each complex project has very explicit and definite criteria that designers need to consider during the model implementation such as stakeholder network complexity and building size in the presented case study. Therefore, applying it on a specific sector or type of projects requires extensive research and empirical studies.

ملخّص

يستكشف هذا البحث التحديات التي ترافق إدارة التصميم في مشاريع البناء المعقّدة , مركزاً على مشاريع المطارات الكبيرة تحديداً, و التحدّي المرافق لإدارة متطلّبات أصحاب المصالح المرافقة لعملية التصميم.

الهدف من هذا البحث هو إيجاد إطار عمل يجمع بين إدارة التصميم من جهة و إدارة متطلّبات أصحاب المصالح في مشاريع بناء المطارات من جهة أخرى.

للوصول إلى الهدف تم استخدام طريقة النمذجة مع الاستعانة بتقنية دراسة الحالة, وذلك لمراقبة وتحليل الوضع الراهن لتحديد العوامل التي تبني النموذج المطلوب. تتطلب هذه الطريقة مراجعة معمّقة لوثائق المشروع و المؤسسه التي تديره و تحليل عمليات الاتصال بين مختلف الجهات المشاركة في المشروع, بالإضافة إلى مقابلة أشخاص فاعلين في عملية تصميم المطارات.

لتطوير النموذج المطلوب, تم إجراء دراسة معمّقة لعمليّة التصميم المطبقة حالياً في هيئة إدارة أحد مشاريع المطارات في دولة الإمارات العربية المتحدة, والمسؤولة عن تطوير أكبر مطار في الشرق الأوسط. إنّ دراسة المشاريع الموجودة في هذه المؤسسة توفر بيئة مثالية للوصول إلى الهدف المطروح في هذا البحث.

بعد دراسة معمّقة لأحدث أساليب إدارة المشاريع, تم تبنّي طريقة منهج جدول العمل (Process Protocol) مع إجراء بعض التعديلات المناسبة لإيجاد الحلول للمشاكل المطروحة في إدارة تصميم المطارات.

يكشف النموذج المعدّل عن أداة فعّالة لمدراء التصميم لترتيب وأرشفة سيل المعلومات في مشاريع المطارات, مع طرح أسلوب عمل لإدارة متطلّبات أصحاب المصالح في عملية التصميم.

في النتيجة , يتبيّن أن كل مشروع بناء معقّد له مجموعة من العوامل المحدّدة التي ينبغي على المصمم أن يأخذها بعين الاعتبار خلال تطبيق نموذج منهج جدول العمل (Process Protocol) , كإدارة الشبكة المعقّدة من أصحاب المصالح, وحجم البناء في المشروع المدروس. لذلك تطبيقها على فئة معينة من المشاريع يتطلب دراسة عملية معمّقة.

Chapter 1 : Introduction

1.1. Research Background

Design work in building construction is a creative and iterative process which is believed to be difficult to plan and analyse in detail. Design management endeavours to establish managerial practices focused on improving the design process, thus creating opportunities for the development of high-quality innovative products through effective process (Tzortzopoulos & Cooper 2007).

Having a clear theoretical foundation for design managers is essential in the modern building constructions, it influences the problems faced in practice. Austin et al (1999) explains that research is yet to provide an overarching framework that could support improvements in practice. This is related to the fact that the main research focus has been on managing design from a designer's perspective only. Also, due to the great diversity of design practice, poor consideration has been given to the importance of context, organizational and project issues in design management which has lead to problems in design management practice. Therefore, clarity is needed as to how different stakeholders should approach design management so that the optimal value and most effective processes can be achieved.

The building construction industry development in the 21st century has added an even greater challenge to the design management. Understanding the project complexity and how to manage it became significantly important for achieving successful projects from the perspective of all involved parties. Cooper (1994) describes how the construction industry is considered to be a risky, dynamic, and challenging business. He adds that with traditional design practices the likelihood that projects would fail and not meet the cost and defined deadline have become increasingly high.

Unlike other industries, researchers used to claim that building construction suffers from isolation of implementation responsibility from design stages. Grilo et al. (2007) supports the statement and argue that the reason is the exclusion of contractors from the design process, and designers undertake responsibility for construction elements that they are not fully aware off. According to Pocock et al, (1997) researchers constantly argue that designers could gain from the early

involvement of contractors, who are usually not involved before tender stage in traditional procurement and design management systems.

The design of modern Airports Construction worldwide such as Passenger Terminal, Cargo Terminal and other Airport Facilities are one of the most complex construction projects nowadays. The construction process for such projects is a challenging task for all parties involved from project initiation stage up to handing over and subsequent operation. It is noted that the complexity of modern airport projects makes traditional design and construction management methods unable to satisfy the project management requirement, which requires dealing with the variety of Airport project components along with the advance technology used for airport operation, moreover, dealing with the huge number of stakeholders involved in the project.

Through experiencing the work in an advanced passenger terminal project, and besides working closely with international consultants of airport projects, it is notable that managing the design of Airport projects is quite challenging task for design managers. Adrem et al. (2006) add that airports design management difficulty is characterized in handling the tremendous amount of information flow in all design stages, dealing with the various disciplines involved in Airport projects, managing the variety of stakeholders involved in the project in all stages, and dealing with complexity of design and implementation of the project.

Airport stakeholders have various interests in the airport building and they are sophisticated according to Schaar and Sherry (2010). Each stakeholder involved in the design of airport is seeking specific goal and objectives which put significant pressure on design managers in terms of finding balance between these, sometimes conflicting, requirements. It is noticeable that no project has reached to handing over stage without notable criticism from the end-users of the facility to the designers (Chinyio & Olomolaiye 2010). However, this statement is not always correct, end-users of the facility do not usually consider all the factors that designers come up with in regards to finding the necessary balance between different criteria impacting the design, hence Cooper et al. (2005) notes the importance of involving stakeholders early in the design process.

The technical complication of an Airport project has a significant impact on the design process. Airport projects usually involve numerous and highly developed systems which requires multidisciplinary teams involvement in the production of

the final design product. Helbing and Lammer (2008) Explain that the involvement of such teams create a complicated network of communication and coordination channels between these disciplines, and that is a characteristic of complex projects. Managing this communication network with the traditional management techniques during design stage usually results in considerable number of missing information and miss-coordination issues, and that will impose a negative impact later during the implementation of the design.

The handling of a complex project creates organizational difficulty that is characterized in the number of sub-projects introduced to form the picture of the generic project. Moreover, it is characterized in dealing with the multidisciplinary issues raised between different departments who are working to deliver the project. This is supported by Wood and Ashton (2010) who explains that such impact is an outcome of the difficulties in communication and handling of the flow of information generated as a result of the project complexity.

It can be argued that there is a need to have a generic framework that supports the management of the design process of complex buildings and the different stakeholders involved in this design process during the project life cycle.

This study examines the main principles of design management in complex project, and focuses on airports design management process and stakeholder interface challenges in the various design stages.

1.2. Research Aim and Objectives

1.2.1. Research Aim

The aim of the research is to examine how to effectively integrate stakeholders' interests and requirement into the complex design process in Airport projects construction.

The research aim can be achieved through answering the following questions

- How can designers manage complex construction design process optimally?
- How can designers manage the variety of stakeholders in complex construction projects?
- How can stakeholders' requirements and interests be interfaced with the design process?

1.2.2. Research Objectives

In order to answer the previous questions, the following objectives are introduced:

- Investigate current knowledge in complex project design and stakeholder management.
- Examine the information flow in the design of complex construction project.
- Explore the stakeholders involved in the design process of Airport construction.
- Examine the validity of an integrated framework of design and stakeholder management in airport construction as complex projects.

It is important to mention that research questions and objectives are focused on airport design as a complex project, and it is believed that the model will have considerable benefits by achieving the following results:

1. Provide clear understating of different relationships interacting within complex building design process
2. Provide a guiding tool for designers to consider the correct design criteria prior executing design tasks.
3. Provide a framework for Airport Construction Organization as to manage design tasks and stakeholders requirement.
4. Provide a base for interface stakeholders and their requirements within design process in order to achieve all parties' satisfaction.

1.3. Research Approach

To achieve the aim and objectives of the research, it is found that producing a framework presenting the structural and interaction levels of complex design and its flow of information from one side, and stakeholders and their interests, roles and involvement from the other side, will achieve all involved parties satisfaction after project completion. This is achieved by dividing the project into 4 phases as follows:

Phase I:

This phase provides an in-depth analysis of the techniques, tasks involved and the information flow in complex design projects in the construction field so that managing the complete design process can be realized by designers and design

managers. A literature review is conducted to find-out the most suitable way for modeling the construction design process. This phase is developed by examining the existing models of design process in manufacturing and construction field, followed by studying the characteristics and the distinctiveness of an airport building as complex construction project.

Phase II:

The existing practices and techniques used in stakeholder management are investigated in this phase. The airport stakeholders are introduced and their goals from airport building are examined. The characteristics of the complex organization, relation and expectation of these stakeholders are tested in order to develop sufficient understanding about integrating stakeholder management in the design process.

Phase III:

In this phase a research methodology is developed in order to define the approach to be followed for developing the desired model. Later, an in-depth analysis of existing practices in the design of Airport Projects is conducted along with stakeholder management, in order to define the potential areas for improvement.
This study is achieved through implementing the case study methodology principles, and through carrying out interviews with designers and employees involved in the construction of one of the largest Airport Terminal Buildings in the Middle East in addition to international airport experience worldwide.

Phase IV:

The findings of the analyzed reality is used in verifying the modern construction design management models (ADePT & Process Protocol models) and the verified results are consequently used in developing modified model of Process Protocol as to address the case study problems. Since empirical validation of the proposed model has certain difficulties, virtual simulation is conducted on one of the design phases of an airport project, and the results are presented to concerned focused groups in order to receive their feedback to test the validity of the proposed model.

Chapter 2 : Literature Review

This chapter builds up the knowledge about design management, project complexity, stakeholders' management and the aspects of airport construction projects. The knowledge is built through examining the design management models used in manufacturing and construction, defining the aspects of complex construction projects, examining the techniques used in managing stakeholders in construction, exploring the area of complexity in airport construction and develop understanding for the stakeholders in the airport.

2.1. Design Process

Design is one of the oldest skills that humanity adopted to serve their needs (Suh 1990).The concept of designing had the same meaning of making till the modern industrial societies were the two concepts are separated (Cross 1989).

In the modern industry design Process may be described from two perspectives (Usmani & Winch 1994). The first perspective believes that design process characteristic is similar between all disciplines and that is supported by Gregory (1966) and Stauffer (1989), the second argues that it varies between different sectors such as construction and industry (Cross 1984).

Many researchers agree that construction can learn from industry, and Howell (1999) suggests that construction can learn from manufacturing's solutions development, and manufacturing can learn from the project-based construction management.

Recent researches according to Cooper et al. (2005) have led to the development of the 'Construction as a Manufacturing Process'. The similarity in design between construction and manufacturing is that both of them begin with a need (French 1991), the design process in both consists of solving series of problems and sub-problems (Cross 1989), and design process itself is an iterative process (Epppinger 1991). Bruce and Biemans (1995) go further and explain that product development is fundamental in stimulating and supporting economic growth for companies and for wealth generation. In many industrialised nations product development and design activities are very powerful corporate tools.

2.1.1. Manufacturing Design Process

Kagioglou et al. (1998) suggest viewing construction design process from the point of new product development process in order to improve the practices in construction such as coordination and communication between parties. The informal and unstructured learning process, contractual disputes, lack of customer focus and unpredictability of delivery time, cost, profitability and quality, are addressed more thoroughly in manufacturing industry. Product development is historically viewed from three points of view:

Sequential Approach

This provides serial approach for the product development through logical step by step fashion (Imai et al. 1985) as shown in Figure 2.1, and allows the organization to take decisions about the product concept and design before proceeding to manufacturing through ensuring satisfaction of each stage before proceeding to the next one (Stoll, 1986). There is similarity between the sequential process and the traditional construction process in terms of following sequential isolated steps that leads to the final product which means design activities are isolated from the issues faced during testing and manufacturing.

This approach also provides highly linearly linked steps that breaking between the phases is very hard. The steps are usually a result of the organization structure where each department requires playing certain and specific limited role in the phase (Hayes et al. 1988). The iterative movement between design and manufacturing results in long lead times, late product launch, increased development costs, lack of information flow and flexibility for change in the process as suggested by Oakland (1995) and, Deasa and Schmitz (1991).

Takeuchi and Nonaka (1986) explained how this process offers high staff utilisation and is suitable for large scale projects where high number of personnel involved and extensive coordination and communication is required. Table 2.1 provides summary of Sequential Approach.

Advantages	Disadvantages
Logical Step-by-step fashion (Imai et al. 1985)	Linear with very hard breaks between phases
Undertake concept decisions, designing of the product and testing prior to manufacturing system design, process planning and production (Stoll 1986)	Linked to the organizational structure of the company, i.e. each department plays specific and limited role in the phase (Hayes et al. 1988)
Ensuring satisfaction of each stage requirement before proceeding to the next stage.	Omitting an element of the product in the early stage will have consequential effect on the other stages and might impose major failure (Oakland, 1995) as a result of cascading effect (Helbing and Lammer 2008)
Similar to construction process (Cooper 2005)	Long lead times, , high development costs, late product launch, lack of information flow and not flexible for change in the process (Deasa and Schmitz 1991)
High staff utilisation in departments (Cooper 2005)	
Suitable for big and innovative projects where product development is masterminded by a genius handling defined complex product specification (Takeuchi and Nonaka 1986)	

Table 2.1: Summary of Sequential Approach

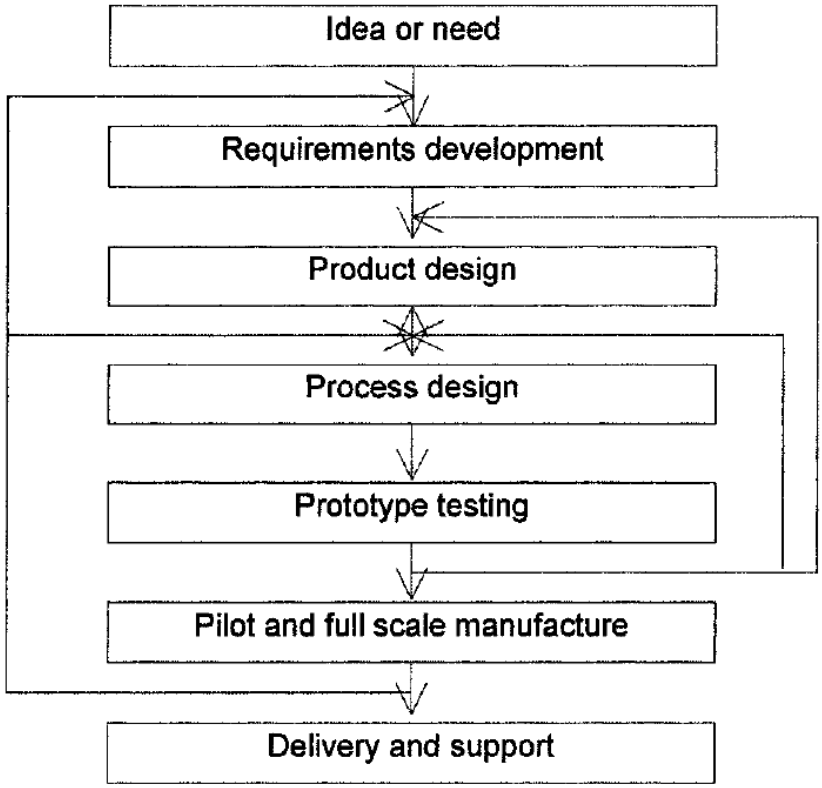


Figure 2.1: Sequential Approach Model (Cooper et al. 2005)

Stage-gate Processes

This process is presented by gates at the end of each stage as shown in Figure 2.2. This requires performing a number of activities and gathering information in order to proceed to the next stage. The process requires cross functional teams to reduce risk, setting phases objectives and improving focus according to Rosenau (1990).

The gates acts as decision points for the mangers for meeting the stage requirement, and it acts as quality control checkpoints. The stage gate process as believed by LaPlante and Alter (1994) reduces the product development time, produces a product that meets market needs and optimises internal resources by eliminating projects that are not promising.

The stage gate process as remarked by Cooper and Kleinschmidt (1991) takes long time to be learned and performed by the executers. Cooper (1994) explained how the project must wait at each gate to complete all required tasks which causes the project to slow down. Moreover, the process might get complicated when dealing with products requires precise definition and minute details and that

makes the process hard to understand, manage and learn. In addition to that, the system becomes bureaucratic and the process too slow.

Hence there is a need to overlap the process to allow for flexibility and speed, and address the issue of the hard bureaucratic gates according to Cooper (1994). Table 2.2 concludes the Stage-gate Processes.

Advantages (LaPlante and Alter 1994)	Disadvantages (Cooper 1994)
Reduce development time	Process takes too long to learn and perform (Cooper and Kleinschmidt 1991)
Produce marketable products	Project must wait at each gate to complete all required tasks
Optimise internal resources by eliminating projects that are not promising.	Overlapping is not possible
	Process might get complicated when dealing with products requires precise definition and minute details
	Sometimes the system become bureaucratic

Table 2.2:Summary of Stage Gate Analysis

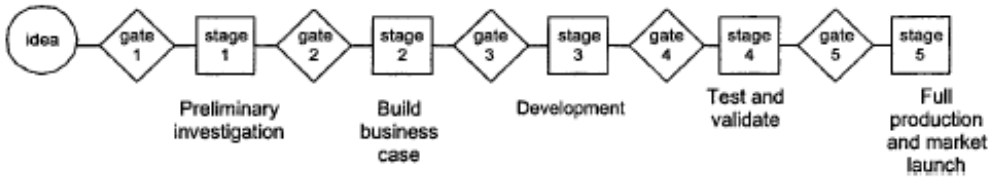


Figure 2.2:Stage Gate Process (Cooper and Kleinschmidt 1991)

Overlapping Process

Cooper (1994) suggests a third generation of new product process as shown in (Figure 2.3) which allows overlapping of the stages in order to solve the discussed

disadvantages. The solution comes through converting the rigid gates to have more tolerance by making it conditional or situational.

Conditional gates makes the decision subject to a task being completed at a specified point in time and the results of that task indicating that it is still a valid project. Situational gates refer to allow making decision when the information from a task that is not yet complete is not crucial enough to suspend the project.

The decision in the overlapping process is shifted from managers to the team involved in the task, and the task remains sequential between the stages. It is noted also that cross checking is still required to follow up the tasks which are not completed.

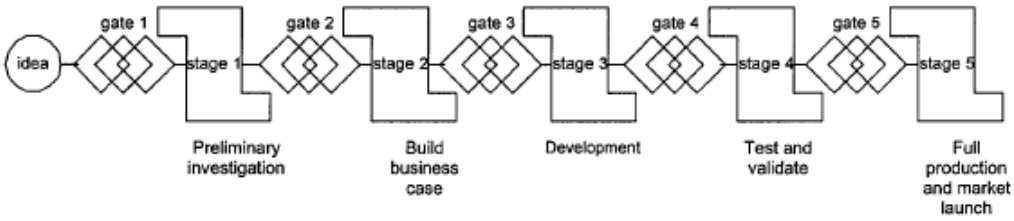


Figure 2.3: Overlapping Stage- gate Process (Cooper 1994)

The advantage of this approach is that decision making authority is shifted away from senior management toward team leaders resulting. However, the disadvantages of these flexible gates is that it requires follow up to solve the halted issues, moreover, the process is still sequential between consecutive stages

The Development Funnel

There is no single model which can be used to develop a new product. Moreover, there is a need to combine a set of tools and philosophies together as suggested by Smith and Reinertsen (1991). Products and processes vary in many ways such as complexity; level of technology required; duration, markets and organizations. Hence Cooper et.al (2005) suggests that there should be a balance between selecting the approaches that allow for speed and flexibility, and those offering focus and control.

Wheelwrigh and Clark (1992) introduced the Development Funnel concept illustrated in Figure 2.4. The process is divided into three phases, the first phase describes the interaction of developing ideas, conceptualize the design, and discussing the requirements. This phase has what is called Screen 1 which defines

appraisal point performed by mid-level managerial group to identify the go/kill decision at screen 2.

Screen 1 provides check point for

- Idea fitting with technology
- Product market strategy
- Applicability in the firm with the available resources.

Screen 2 is seen as a gate in similar way of Gate Process, this screen is controlled by senior management that conduct a revision of the products and process used to the developing projects.

It is noted that the model allows flexibility within each phase and that addresses the issue of sequential between the consecutive gates, while the screens acts as hard gates to move from phase to phase.

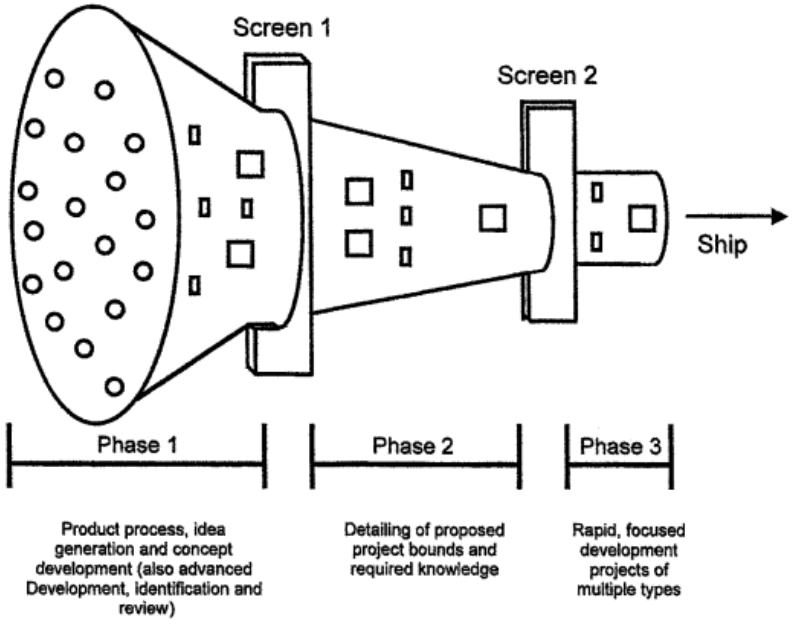


Figure 2.4: Development Funnel (Wheelwrigh and Clark 1992)

Newton (1995) reviewed the manufacturing design process models from three perspectives.

Descriptive Models:

These types of models describe how product designers perform the design process. Luckman (1984) discusses typical descriptive model as shown in Figure 2.5 which begins from analysis to synthesis and evaluation for problem solution.

Analysis stage involves collecting and classifying the relevant information of the product or problem, while synthesis stage forms the potential solutions for the design problem or product. The evaluation stage attempts to judge by the use of criteria that satisfies the response to the problem.

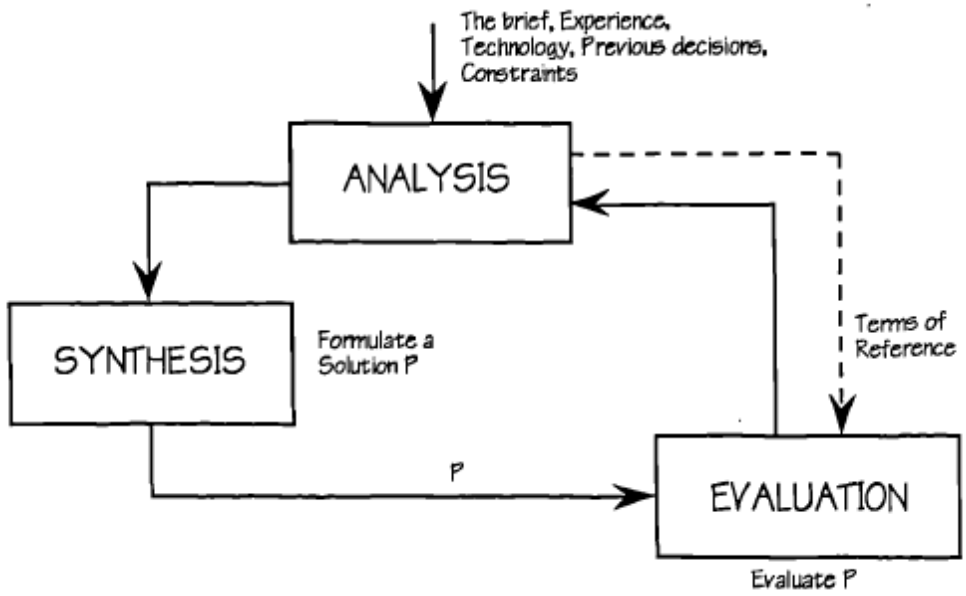


Figure 2.5: Descriptive Model (Luckman 1984)

Prescriptive Models

These models provide systematic proposal for designer to handle the design process. As suggested by Cross (1989) these models provides systematic procedure to follow and it is argued that they impose particular design methodology, figure 2.6 reveals example of descriptive model. As the Figure shows, the model starts by establishing the needs, perform analysis for the needs, produce conceptual design, model the design and proceed for detailing if the concept has gained satisfactory levels.

French (1991) argues that the prescriptive models tend to describe what activities should be performed in the design process rather than how activities should be performed. It is noted that these models act as a dictating tool for designers to work in a systematic manner.

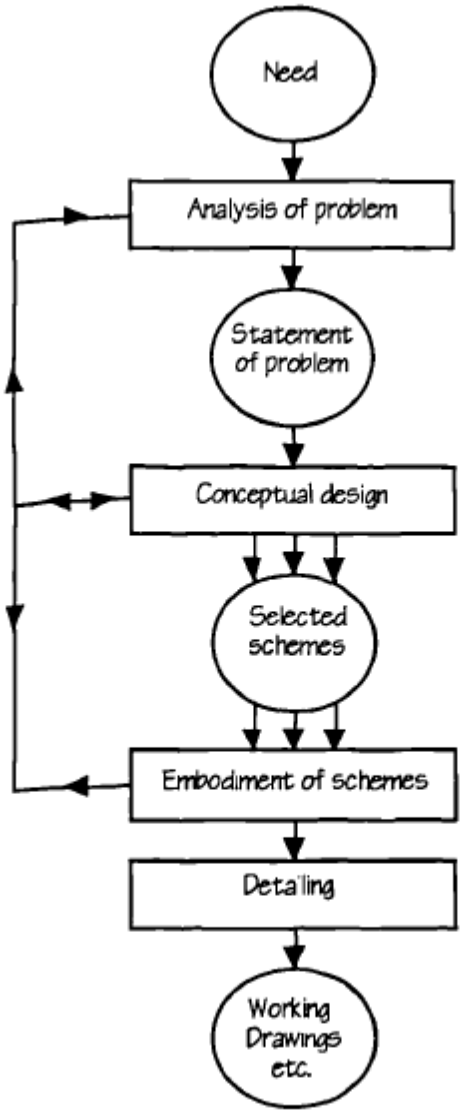


Figure 2.6: Perspective Model (French 1991)

Consensus Models

These models are combination of both prescriptive and descriptive models. It provides a description of the design process flow in the vertical axis, and provides the solving process in the horizontal one. An example of such model developed by Pugh (1990) is shown in Figure 2.7. The model describes how the model core forms the steps through which design should be processed. The main flow of design work is described by bold arrows vertically while each stage have procedures to be implemented in order to complete the design activity and this is shown horizontally.

Although the model reveal the information required at each stage however, it is noted that the model does not permit the feedback flow as explained by Newton (1995).

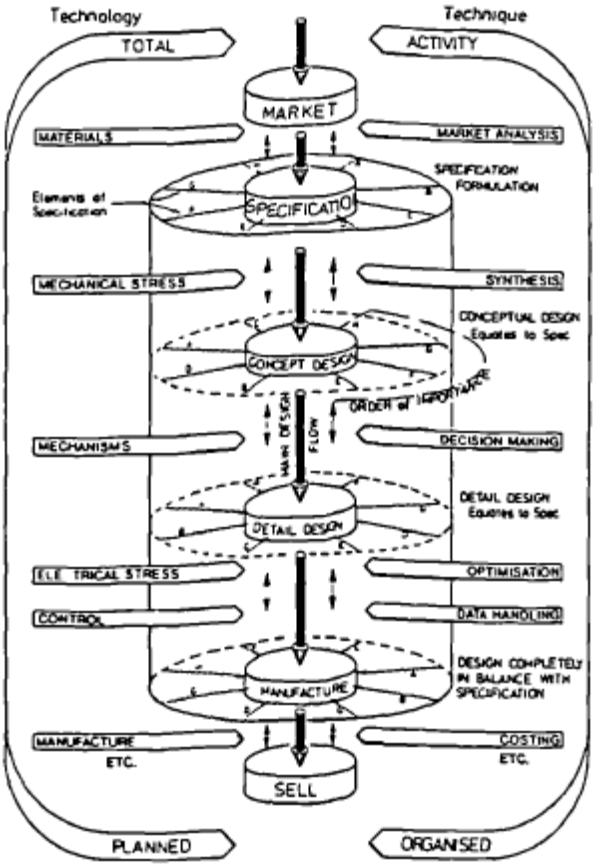


Figure 2.7: Total Design Model (Pugh 1990)

Conclusion of Manufacturing Models

Researchers always highlight difficulties in using manufacturing models practically in construction domain (Taylor 1993). Hiller et al. (1984) argues for example that descriptive models cannot be applied to the architecture design process. The architects usually develop a solution first and they subject the solution to analysis and evaluation rather than problem analysis preceding development of solution synthesis.

The targeted design process should provide systematic approach for design solution; give designers what steps to be performed and how to perform these steps. However, it should not be rigid while moving from stage to stage. Flexibility should be in place to allow moving to next stage if the designer feels

that work can proceed subject to address certain issues later as seen in overlapping stage gate process. Design validity and quality control should always be performed to avoid product or project failure in late stages of design process.

2.1.2. Construction Project Design Process Models

Austin et al (1999) claims that construction lacks standard project process, but there are several recognised models for the construction process which are commonly used. This research will discuss the Royal Institute of British Architects (RIBA) plan of work (1964), the British Property Federation (BPF) manual (1983) and Wix's Model for Representing the Design Process (Wix 1986).

RIBA Plan of Work

The RIBA Plan of Work shown in Figure 2.8 has become widely accepted as standard method of operation in the construction industry according to Kagioglou et al. (1998).

The model has two dimensional axes for the design process. The stage of the project is shown on the vertical axis while the involved discipline is shown on the horizontal one.

The model show twelve phases representing logical sequence for design process. Each stage has eight design functions performed by various disciplines leaded by architects who are responsible for dealing with client and design team. Therefore, the model performs two functions which are design function and management function.

RIBA (1997) describes the typical design function in RIBA model which includes:

- Design studies and work to be performed in the design stage.
- Proposals and options to be considered in design.
- Decisions and actions to be taken.
- Discussions and meetings to be accomplished.
- Information that needs to be elicited and provided.

The process provides logical sequence of events and ensures timely decisions are made for each step. The model also forms the basis for integrating different

disciplines in the construction process and therefore, it forms the basis for performing design management.

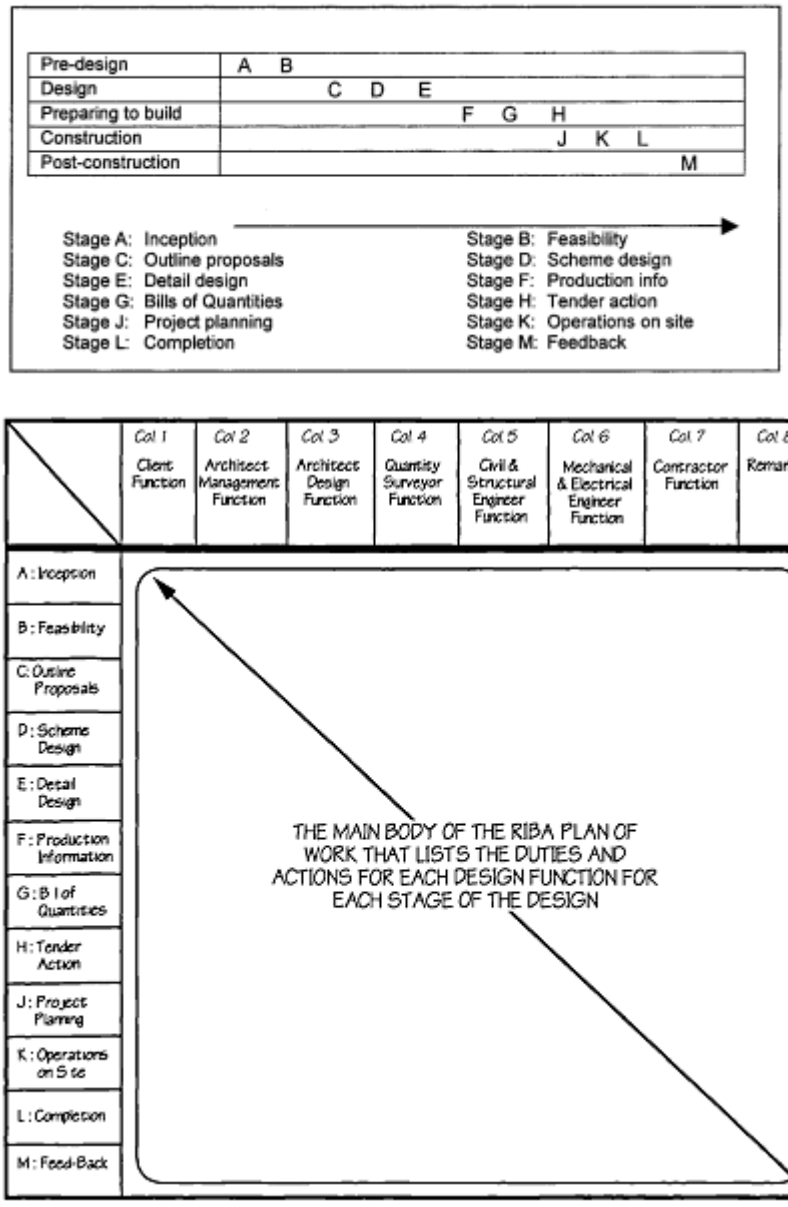


Figure 2.8: RIBA Plan of Work (RIBA 1997)

Newton (1995) & Cooper et al. (2005) argues that the RIBA plan of work lacks the detailing aspect of the design process, hence it performs as a checklist tool and generic planning tool for the parties involved in the design process and therefore, it cannot be adopted as a tool for individual participants work on a day to day basis. (See summary in table 2.3)

Advantages	Disadvantages
Logical sequence of events and ensure timely decisions are made for each step	Designed from Architecture point of view
Forming the basis of the terms of engagement between parties	The stages are presented in linear fashion, i.e. next stage cannot start before completing the previous one.
Provide a systematic framework for design management	Not detailed enough to schedule individual activities
Promote management functions such overseeing design work and task co-ordination.	Too generic to plan the individual participants work on day to day basis and does not support detailed design

Table 2.3:Summary of RIBA Model Analysis

Wix's Model for Representing the Design Process

This model was developed based on the Flow chart technique to produce process models for construction works as explained by Addis (1990), this model divides the work into well defined sections, and each section has its own flow charts. The model provides a link for the information that flows between these charts as shown in figure 2.9. Wix (1986) divided the data feeding this model into three categories.

1- Fixed Data which is independent of individual project like the physical properties of materials, details and regulation.
2- Project Data which is specifically related to the project and communication between disciplines in the design team and that includes specifications, financial data, dimensional data and project performance data.
3- Transient Data which is the Data produced and then solely utilized by another process in a single discipline. For instance, the process of calculating the amount load on the structural slab for designing the slab, and then utilizing the same information in the process of designing the structural columns.

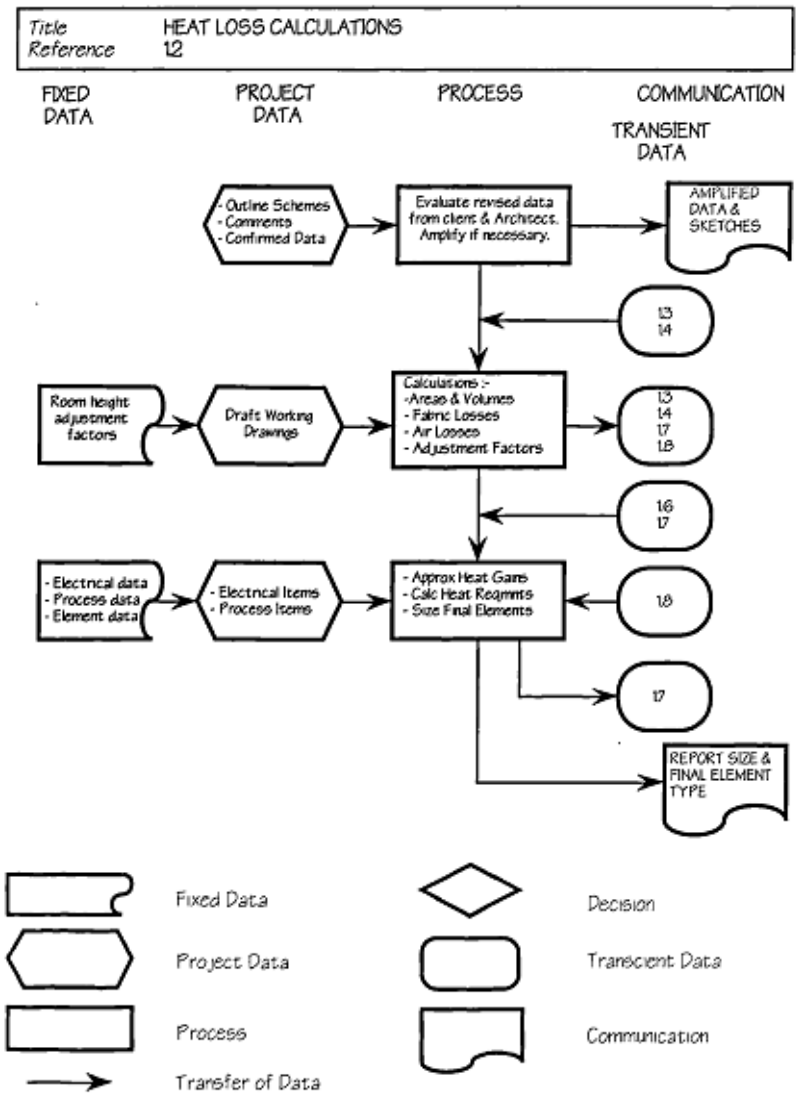


Figure 2.9: Example of Wix Model Application (Wix 1987)

Newton (1995) explained how Wix model provides detailing procedures for the design process. Moreover, it describes the process and consequential flow of information of design data. However, the model is built based on the flow charting technique hence it inherits many of their failings such as the pre-defining and sequential task ordering. In addition to that, the technique does not deal with the originator of cross discipline information, in other words it does not facilitate the integration of different disciplines in the design process as it was made for mechanical services design. Table 2.4 summarize Wix's model.

Advantages	Disadvantages
Provide detailed account for design process	Inherits the flowcharts charting methodologies failures such as pre-defining and sequential task ordering
Describes the process and information flow of Data	Difficult to show succinctly the originator of cross discipline information.

Table 2.4: Summary of Wix Model Analysis

British Property Federation (BPF) Model

This model is developed to overcome the increasing problems in the construction industry such poor design, poor choice of materials and lack of supervision as explained by Kagioglou et al. (1998). The model is designed to involve all parties in the design process such as stakeholders, consultants, contractors, subcontractors and suppliers which is not considered in RIBA plan of work. The model highlights the relations between these parties in order to provide the client with value for money design solution. The model divides the design process into five stages.

1- Concept
2- Preparation of brief
3- Design development
4- Tender documents and tendering
5- Construction.

Cooper et al. (2005) found that the model is flexible as it allows the client to make decisions by the end of each stage. The model considers the value engineering and work speed up, and the study of the project at initial stage helps in removing the overlapping of efforts between design team members and, reduces delays and variations. However, the model has not been widely used due to its close link with repetitive house building projects in the UK. Table 2.5 is a summary of BPF model analysis.

Advantages	Disadvantages
Provide the client with value for money	Not widely implanted due to its close link with repetitive house building projects
Allows the client to make timely decision to proceed from stage to stage	
Better building in lower cost	
Removes the duplication of effort between designers	
Tackle difficulties at initial stages of the project	

Table 2.5: Summary of BPF Model Analysis

Contractor Involvement in the Design Process

During the development of construction industry, there are several attempts to alter the design process structure and process to promote the information flow and reallocate risk through introducing new mechanism such as design and build, prime contracting, partnering, management of the supply chain. These attempts are targeting bridging the gap between design and construction activities by bringing design phase into the front end to improve design- construction interface. Although such processes have their implications and not many of them are applicable to any project as explained by Kadefors (1999), however the contribution of the specialist organisations is important as they have specific knowledge about the construction material, product performance and site operation. Love et al. (1998) believes that the early commitment to the project cost in design stage is a key success factor for such process.

Finally, it is argued that the involvement of contractor at design stage has vital impact on having "right first time" design, and will have positive impact on the constructability, quality, efficiency and speed of the construction project (Ettle & Stoll 1990, Cooper & Klienschmidt 1994 and Cooper et al. 2005).

From the presentation of the commonly used design process management in industry and construction domains, it is notable that industrial models are more detailed and specific while construction models are general and performs as a guideline, each of these presented models have its advantages and disadvantages. Therefore there is an opportunity to develop a holistic and flexible process model that involves front –end and cross functional teams in the design process. It is required to have better process definition that can address the changes in flexible manner, involves stakeholders in the design process and provide consequential steps without neglecting the details required to achieve each stage.

2.2. Techniques Used for Managing the Design Development Process

Design process techniques are essential tools for supporting design management models and, for teams and disciplines integration and coordination. Simple mechanisms are commonly used in construction such as flow charts or Gantt charts. However Cooper et al. (2005) believes that these techniques are limited in complex projects. Hence advanced techniques are advised to be used. The following summary of literature encapsulates advanced techniques used in construction and manufacturing. It will present a general review of some of the used techniques used in different disciplines and later the suitable techniques in construction will be explained at more depth.

Integrated Definition Language (IDEF) or Integrated Computer Aided Manufacturing Definition

This technique shown in Figure 2.10is widely used in manufacturing industry. It consists of inputs data entering the activity zone and processed to produce outputs. The conditions required for the activity are controlled and specified to produce outputs while mechanisms are means which supports execution of the activity. The System analysis and design is conducted through this model for the entire enterprise (such as people, machines and material) as explained in IDEF (2002). This technique promotes communication between designers, users and managers, and provides an area for sharing general understanding of the process. It is recommended for complex projects as it provides powerful tool for information management as explained by Austin et al (1999).

A more detailed explanation will follow later in the research as it is one of the suitable techniques to be used in complex construction projects.

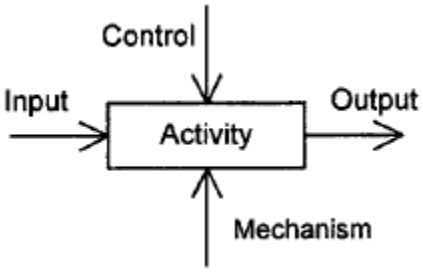


Figure 2.10: IDEF Technique (IDEF 2002)

Analytical reductionism/process decomposition

As shown in Figure 2.11, this technique decomposes the process down into levels of granularity. It makes further sub-processes that defining their corresponding upper-level process. The technique as remarked by Cooper et al. (2005) does not provide a differentiation between process and procedure which is still a topic of contention in the process management field. However this concept is beneficial when it is used in simplifying and dividing the project design work as will be explained later in advanced construction design management frameworks.

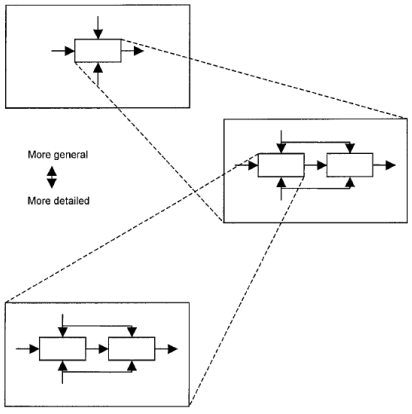


Figure 2.11:Analytical Reduction / Process Decomposition (Cooper et al. 2005)

Data Flow Diagrams (DFDs)

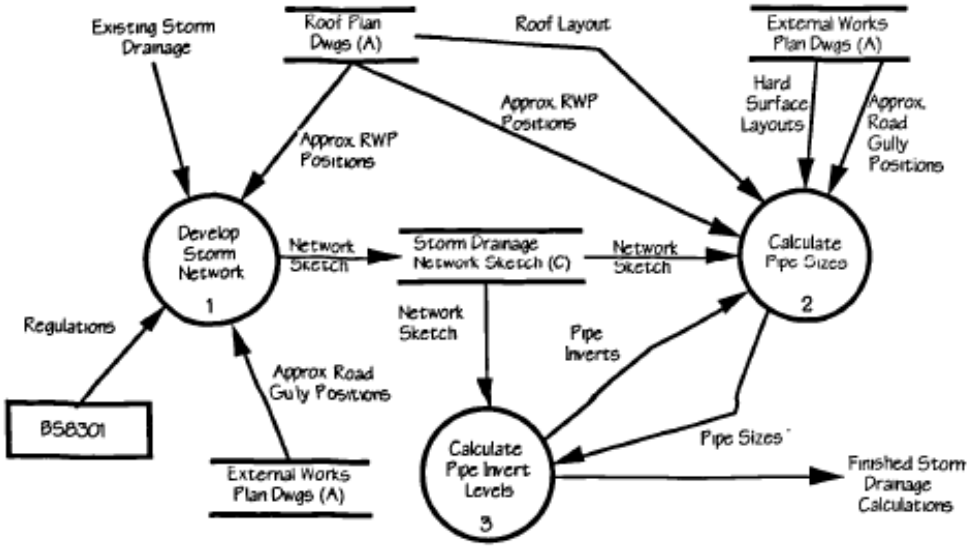
This technique is widely used in construction design processes. DFDs are typically made up of four main elements. These elements are shown in Figure 2.12 and are listed as following:

Data flows: Those are pipelines of known composition of information flow.

Processes: Those transform the incoming data into outgoing data

Files: Those are a temporary storage of data.

Data sources or sinks: Those are a person or organisation lying outside the context of the system



ELEMENT	SYMBOL	SOFTWARE DEVELOPMENT DESCRIPTION
DATA OR INFORMATION FLOW	→	A connection between processes etc., representing an input and/or an output.
PROCESS	○	Individual functions that a system carries out. They transform an input into an output.
DATA STORE OR FILE	=	A collection of information that must be remembered for a period of time.
SOURCE/SINK	□	External entities with which the system communicates.

Figure 2.12:Example of DFD's by DeMarco (1979)

DFDs are capable of modelling processes and information flow between them. DeMarco (1997) added that DFD's view the system from informational point of view and it provides mapping of information flow with their transformational and

coordination perspective. The DFD's will be discussed later in details in this research.

Structure Charts

These charts are used mainly in IT domain. As shown in Figure 2.13 the structure charts are hierarchical diagramming technique that uses functional decomposition to examine a system and construct a model that goes from the most general representation at the top to the more specific at the bottom.

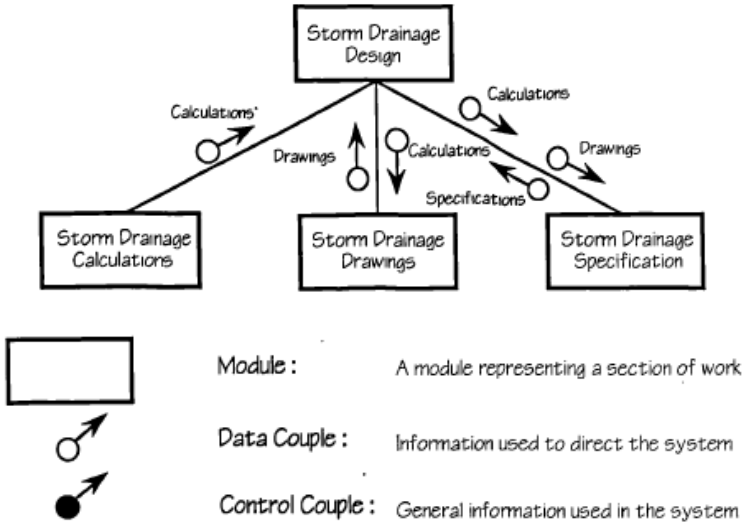


Figure 2.13: Structured Charts (Yourdon and Constantine 1979)

These techniques provide modelling for both tasks and information flow between them. And they have the advantage of not imposing a sequence or order upon tasks which facilitate the representation of iteration.

Jones (1989) discussed that these techniques are not suitable for large systems as it does not deal efficiently with large flow of information, hence it might be not suitable to be used in complex construction.

Continuous improvement CI

This technique is widely used in Quality management. The process is performed as shown in Figure 2.14 through closed circle consisting of the following zones:
Plan: where the problem or opportunities for improvement is identify,
Do: implement the plan and document the changes
Check: examine the revised processes to test the achievement of the goals
Act: regulate document and disseminate the results.
The technique provides an incremental change process that focuses on performing existing tasks more effectively. It can be useful tool for improving design process as suggested by Oakland (1995).

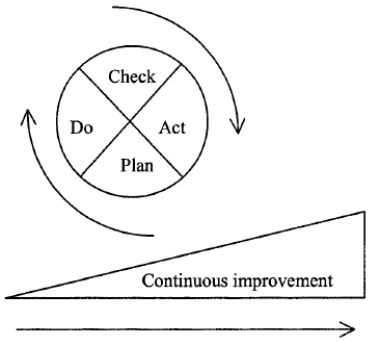


Figure 2.14: Continues Improvement (Oakland 1995)

Conclusion:

There are several techniques used to manage the design development process. The main function of these techniques is to provide a visual understanding for the design process, provide management tool for the detailed parts of the design and provide hierarchical model for information flow.
There has been a significant concentration on the development of construction building model and development of 3D CAD modelling with other design criteria such time and cost which can be shared with all parties involved in the design process and help in forecasting and planning the construction process.

Suitable Techniques for Design Process Models

DFD's are considered as one of the appropriate technique to be used in construction projects design model according to many studies (Fisher 1990, Fisher

and Lin 1992, Austin et al 1999, Gharib 1991 and Pollard and Plumer 1993). Fisher (1990) believes that the following properties promote the DFDs to be used in the construction design process:

- They are graphical.
- They can be partitioned.
- They are multi-dimensional.
- They highlight the flow of data fairly than control.
- They represent a situation from the viewpoint of the data rather from the viewpoint of a person or an organisation.

IDEF0 is an advance technique of IDEF methodology explained earlier which is developed for US aerospace industry for better manufacturing communication and productivity. The methodology is based on modelling information, dynamics, functions and processes. Austin et al (1999) finds that functional modelling is established when applying IDEF0, and a process can be applied from the viewpoint of the information within it more willingly than its sub processes which has been remarked as a need of a building design model. IDEF0 activities transform an information input into an output. However there is no modelling for the internal mechanics of the transformation. Each process or activity can be divided explain more detail in another sheet to guarantee that the main diagram does not become too weighty.

The common feature between DFD and IDEF0 are:

- Providing top-down analysis which allows the top parts to explain a generic view of the system and then provide more details at the lower levels for further study.
- Both of them are graphical and easy to read
- The model size is manageable
- They provide description of the process from the data point of view rather than organization point of view hence they can be used as generic technique of organizations.
- Iterative procedures can be modelled

Austen et al (1999) believes that IDEF0 are featured in representing the data flow and control and mechanisms of process or resources while DFDs allow showing the physical source of data. DFDs have disadvantages that it needs maintaining careful use and clear understanding. It appears to be simple however it might provide fake sense of sequence and it is hard sometimes to give decision where the data in some areas has originated from.

Austen et all (1999) reviewed the IDEF0 methodology and produced IDEF0v which provide information inputs from the same discipline activities that are different from those in other disciplines forming an external sources for instance the client or stakeholders. This modification is suitable for dealing with different types of information flow (Figure 2.15)

The difference between IDEF0v and IDEF0 as remarked by Austen et al (1999) is

1- Intra-disciplinary inputs enter from the left
2- Cross disciplinary inputs enter from the top
3- Inputs from external sources enter from the bottom.

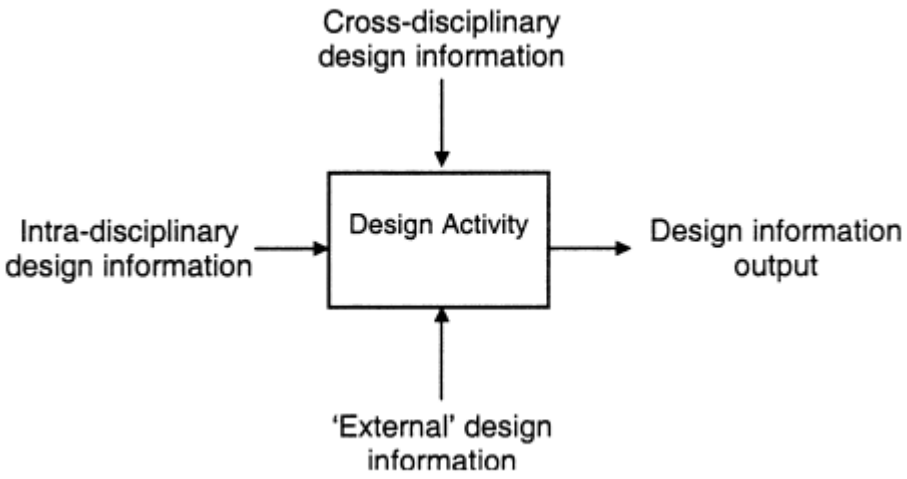


Figure 2.15: IDEF0v by Austin et al (1999)

2.3. Advanced construction design management techniques

2.3.1. Analytical Design Planning Technique (ADePT)

Newton (1995) developed the ADePT methodology shown in Figure 2.16 to overcome the limitation of traditional techniques used in design and planning

construction projects which does not allow an effective understanding for the variation and delays within an iterative process such as design.

ADePT starts firstly in modelling the Building Design Process (DPM) indicating design activities and their information dependencies. In ADePT, such data is linked by a dependency table to a dependency structure matrix (DSM) analysis tool to define design process iteration and schedule the activities with the aim of getting optimal task order as explained by Austin et al (1999). The previous two stages will produce design programms based on the optimised process sequence and through the iteration between the DSM and programming stages.

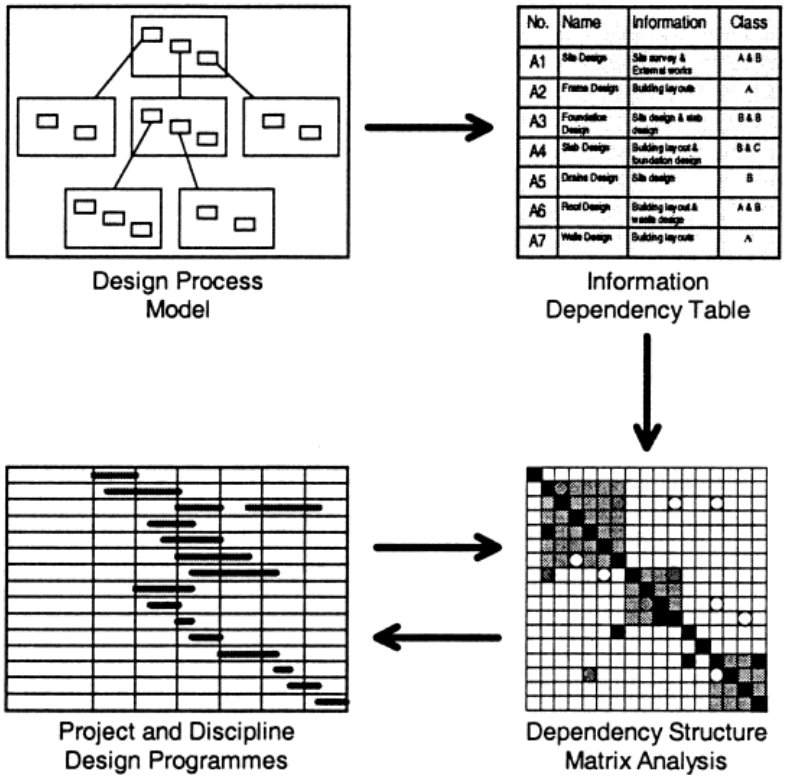


Figure 2.16: Analytical Design Planning Technique (Newton 1995)

Creating the Design Process Model (DPM) and the Information dependency table is in line with the objectives of this research hence it will be explained more thoroughly.

Newton (1995) developed the detail design in two stages. The first is to identify the activities within the generic process along with their hierarchical structure. The second is to identify the information requirements of each bottom level task.

The construction of DPM will be through combining the top-down and bottom-up analytical activities by defining the tasks and the building design hierarchy. This is achieved by:

- **Determining the design process hierarchy** through defining the generic process of building design by listing the sub processes and problems. This takes place through interviewing designers, design managers and design planners.

An example for the high level division is provided by Austin et al (1999) in Figure 2.17.

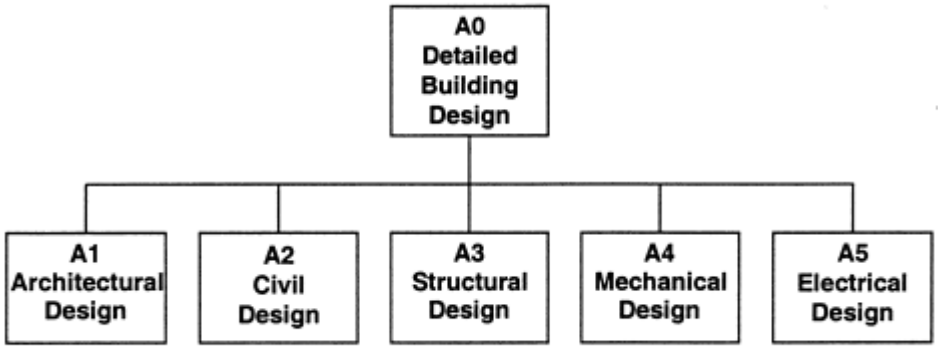


Figure 2.17: ADePT High Level Division (Austin et al. 1999)

The sub- processes are the design of all systems within main design discipline. In each discipline designers provide the building system that fall within that discipline responsibility. The design systems then will be organized to form the appropriate DPM.

Designers will then define how to hierarchally divide the design of each system of the building into sub-systems and components, and how further dividing could be achieved into the lowest level of individual design task.

The design tasks at the bottom level usually are shown in the dependency structure matrix and later when proceeding to the programming stages which are not in this research scope.

- **Determining the information requirements of the tasks:** This stage comes after establishing the activities' hierarchy of the detailed design process. The stage requires establishing the dependencies' information of each design task in order to construct the DPM. Austin et al (1999) explained that this information can be combined in tabular form through input from designers considering that all needed information for design to proceed shall be considered.

- **Establishing design process model diagrams**

The design process diagram is achieved by compiling the identified activities in the hierarchy of the process and the information flows required by each activity. Later it requires the source activity of each intra-and cross-disciplinary information input to be defined. The information flows can be linked to the suitable tasks as either inputs or outputs using DFD's techniques which is adopted by Newton (1995) or IDEF0v adopted by Austin et al (1999) (Refer to the example in Appendix I)

2.3.2. Process Protocol in Design and Construction

Cooper et al. (2005) developed the Process Protocol (PP) based on contemporary problems facing construction sector. The PP sets the scene for developing potential solution for these problems. PP has six key principles developed from the manufacturing industry. These principles are related to recognised problems in construction where improvement is required. The following describes these essential elements of the generic design and construction protocol.

1- Whole project view

In construction industry less concentration is given to the post-construction activities stages and always these stages are accelerated to reach the implementation stage. This practice caused an insufficient identification of the client's requirement. Hence, PP views the whole life of the project from initiation stage till operation stage including all issues from business and technical point of view. Moreover, PP recognises the inter-dependency of activities in the project life cycle and considers the 'front-end' activities in order to promote the identification and evaluation of client needs to reach optimal design solution.

2- A consistent process

The requirement of interface between multi disciplines requires the establishment of consistent generic process protocol in order to achieve consentient application. This practice ensures reducing ambiguity association with the interface application.

Adopting this standard approach to measure, evaluate and control should aid a improving the design and construction process continuously.

3- Progressive design fixity

The concept of ‘stage gate’ which has been outlined earlier facilitates a consistent planning and review protocol through the design process. Phase deliverables review are conducted by completing every phase considering the aim of reviewing the implemented work, and approving the progress to and planning the execution of the next phase.

The principle of conditional approval of the phase gates is translated by developing the protocol’s phase gates. Phase gates according to Cooper et al (2005) are classified either ‘soft’ or ‘hard’. The soft gates allow the possible concurrency in the process while making sure that the key decision points in the process are respected. This approach facilitates the progressive fixing and /or approval of information throughout the process.

4- Coordination

Coordination is a crucial factor in the modern construction which has increased disciplines and specialization as additional complexity factors to the project. The proposed PP undertakes coordination by the process and change management (activity zones). The process manager is the authorized delegate to plan and coordinate the participants and activities of every phase during the process. The coordination principle proposes the position of a change manager to whom all information related to the project is passed and who will support the action of the process manager. In this role the change manager is responsible for interfacing the activity zones and the legacy archive in the process.

5- Stakeholder involvement and teamwork.

Involving stakeholders in the PP is essential in reducing the potential costly changes and production difficulties later on by enabling decisions related to design being made early in the process.

6- Feedback

The phase review process promotes recording, updating and learning lessons from project experience. Hence PP proposes having a legacy archive which facilitates the continued improvement in design and construction.

Process Protocol Elements:

The PP model consists of 10 stages grouped into four broad stages as following:

1- Pre-project stage

This stage is related to the business strategic considerations of the project and aims to address client requirements. The client's need is defined considering:

- Shaping the need for construction project resolution.
- Ensuring the financial authority to authorized proceeding to pre construction phase.

This stage in construction usually given a less concentration compared to latter stages. The previously discussed models such (RIBA) assumes that clients have concluded the needs which is not always the case. Consultants, building developers and client representatives could assist any client in the early stage of the project which will substantially eliminate the problems of incomplete or vague design brief.

2- Pre-Construction Stage.

This stage develops the design through a logical sequence aiming to get approval on proceeding to construction stage. This stage is usually developed after approving the project financing and producing an appropriate design solution that meets the client needs.

The phase review as suggested by Cooper et al (2005) adds the possible for the progressive fixing of the design along with its simultaneous development within a formal coordinated framework. It is important at this stage to reach to design fixity for improving communication and coordination between the involved parties to proceed to the next stage.

The aim of preconstruction stage is to secure full financial authority to proceed to construction stage and after concluding the client is aware of the extent of the works and potential risks can be understood.

3- Construction Stage

This stage concentrates on producing the approved design solution. It is the fruit of all communication and coordination effort done in the preconstruction stage. Theoretically any changes to approved project are going to be minimal as the high cost of change shall be understood by the client.

The concept of ‘hard gate’ that divides the pre-construction and construction phases is not supposed to stop a ‘work-package’ approach to construction and the related delivery time benefits brought according to Cooper et al (2005). It is recommended to grant approval for carrying all concurrence activities in the process through the hard and soft gates concept however significant coordination is required to achieve this.

4- Post construction stage

The aim of this stage is to monitor the maintenance needs of the completed building. Cooper et al. (2005) explained how important is the involvement of the facility management in early design stages which will make post construction stage less problematic. Recording properly the project's legacy archive will result in eliminating the need for surveys of the completed property.

The Activity Zones of the PP

PP approach of design management considers the early involvement of the project participants as crucial practice. The participants in the PP are referred to them according to their main responsibilities and are shown on the y-axis of the process model.

The PP groups the project participants into 'activity zones'. These zones have multi-functional role and represents structure sets of processes and tasks that direct and maintain work in the direction of a common objective (Cooper et al. 2005).

In complex projects the activity zones contain a complex network of people and related functions and/or organisations. The nature of multifunctional aspect requires the membership of the involved delegates in the 'zones' is to be defined

by a precise task and /or process. For instance, there is important input for design management in production zones and facility management zones and vice versa.
The following lists the activity zones in the PP model:

- **Development Management**

This zone is linked to the client /customer of the project. It is responsible for the project success or failure. This zone represents the process stakeholders and it has important role in preparing design brief and managing client and stakeholders requirements.
The development management zone creates and maintains the project business focus, and tries to satisfy both organizational and stakeholder objectives.

- **Project Management**

Implementing the project agreed performance measures is conducted at this zone. It achieves the business and project requirement as set out in the business case and project brief developed in Development management zone.
Project management activity zone identifies the project activities and deliverables, formulation of effective project execution plans, co-ordination of the project activities towards achieving the project requirement, and liaising with process management throughout the process.

- **Resource Management**

This zone looks after planning, procurement, coordination and monitoring of all the human, financial, and material resources of the project (Cooper et al 2005).

It ensures that all cost estimates and purchasing of goods and services are meeting the project requirement zone needs.

- **Design Management**

Translating the business case and brief into product is done at this zone. It works as a guidance and integral zone for all other activity zones.

- **Production Management**

This zone is adopting the best solution for implementing the design, the logistics of construction and organisation for product delivery.

- **Facilities Management**

Ensuring the cost efficient management of assets is implemented at this zone. It creates an environment that supports the building owner objectives and users.

- **Health and Safety, Statutory and Legal Management**

This zone is responsible for health and strategy, statutory and legal management aspects of the project.

- **Process/Change Management**

This activity zone has an independent role compared to all other zones. It is responsible of enactment of the 'process' rather than the 'project'.
It ensures facilitating and coordination of the disciplines to produce the final product. Moreover, it monitors the implementation of each phase as planned and culminating in presenting the deliverables at the end of each phase review.
Change management concerns managing the changes occurring during the process. According to Cooper et al. (2005) the project will be gradually more defined when each phase is ordained and changes to the information needed for the project development will be produced. These updates will be embedded in the required work to develop the deliverable documentation related with each phase. Change management promotes the review, dissemination, and holding of this information through the project.

The following Figures (2.18,2.19,2.20) illustrate the PP model.

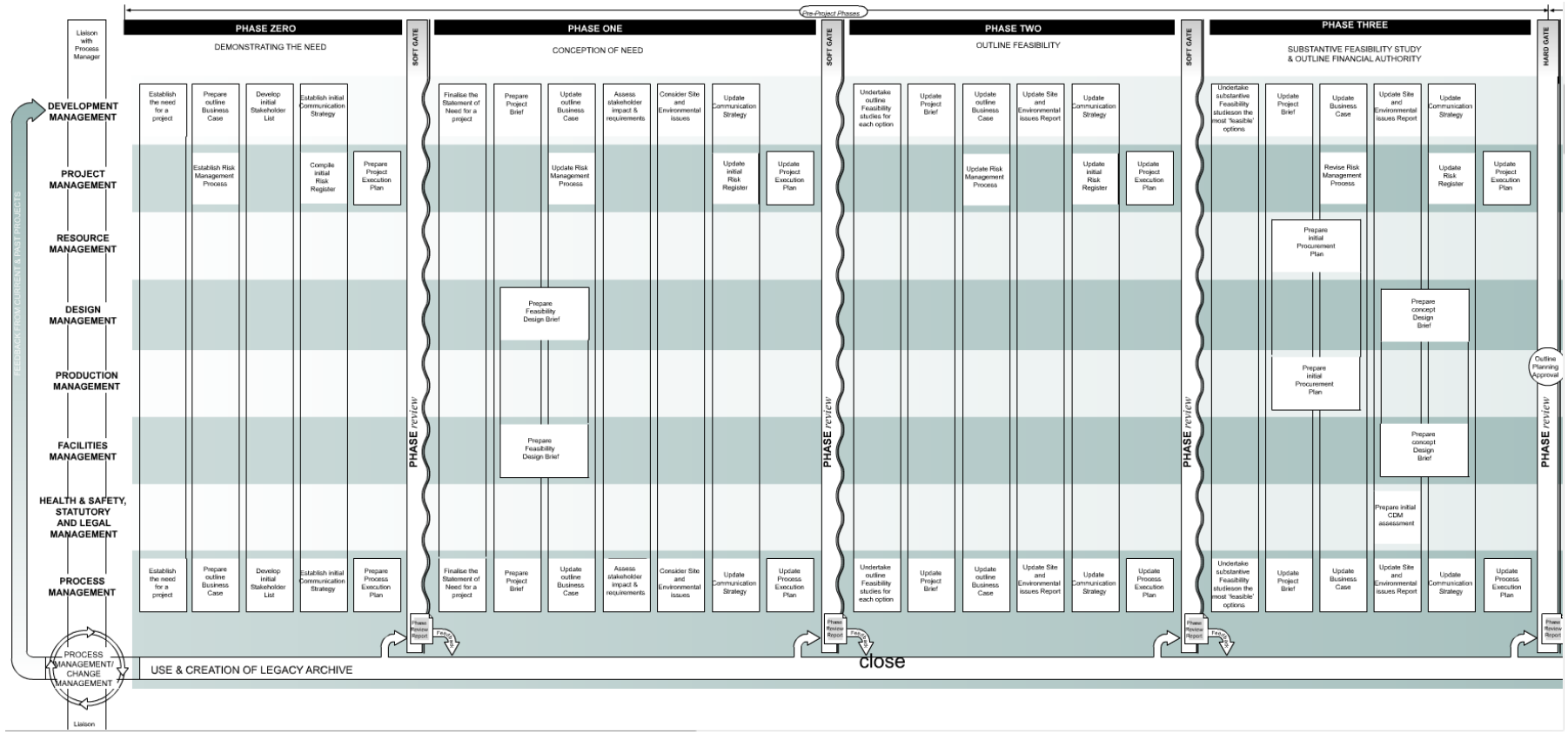


Figure 2.18:Pre-project Activity in the Process Protocol (Salford University 2002)

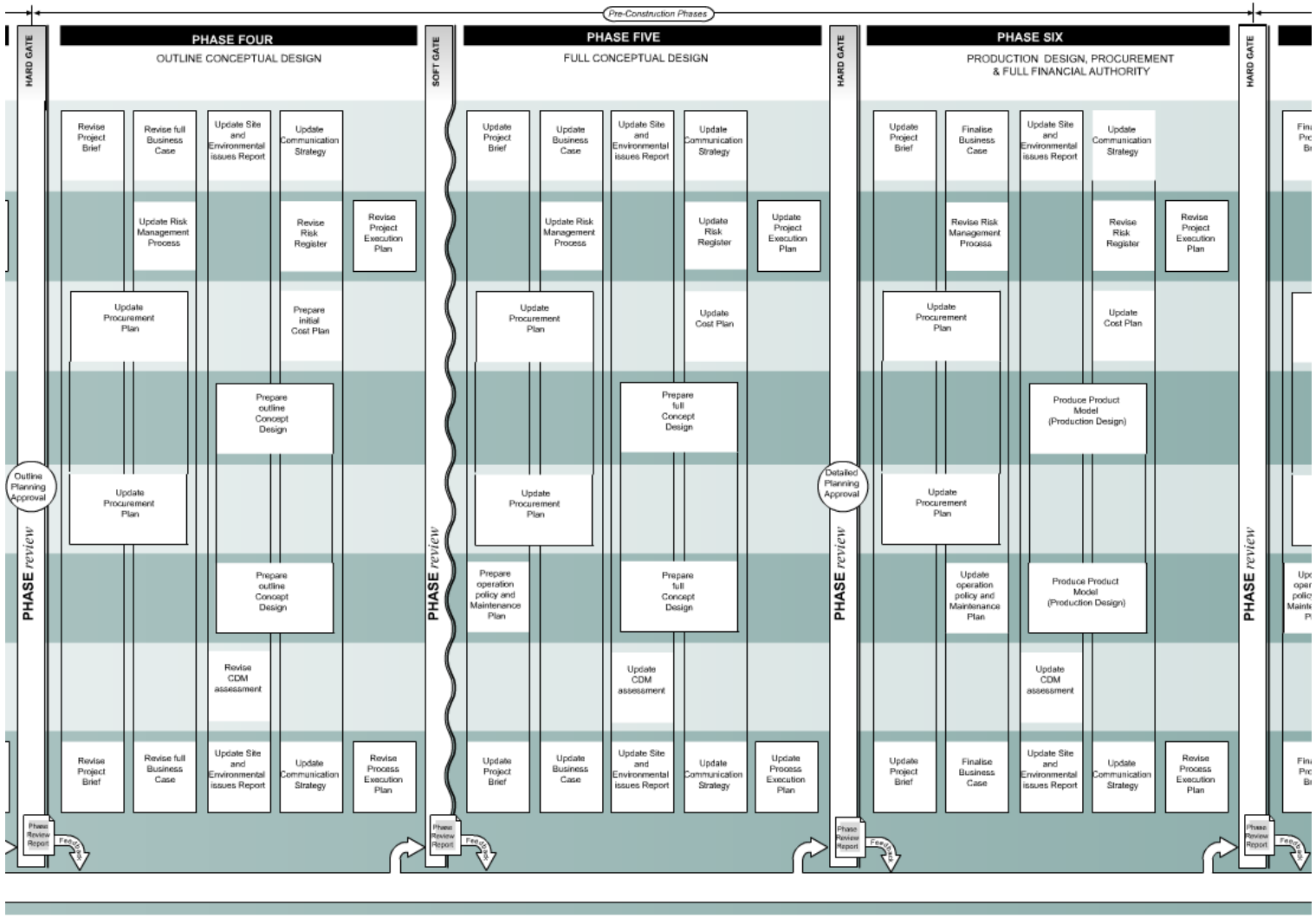


Figure 2.19: Pre-construction Activity in the Process Protocol (Salford University 2002)

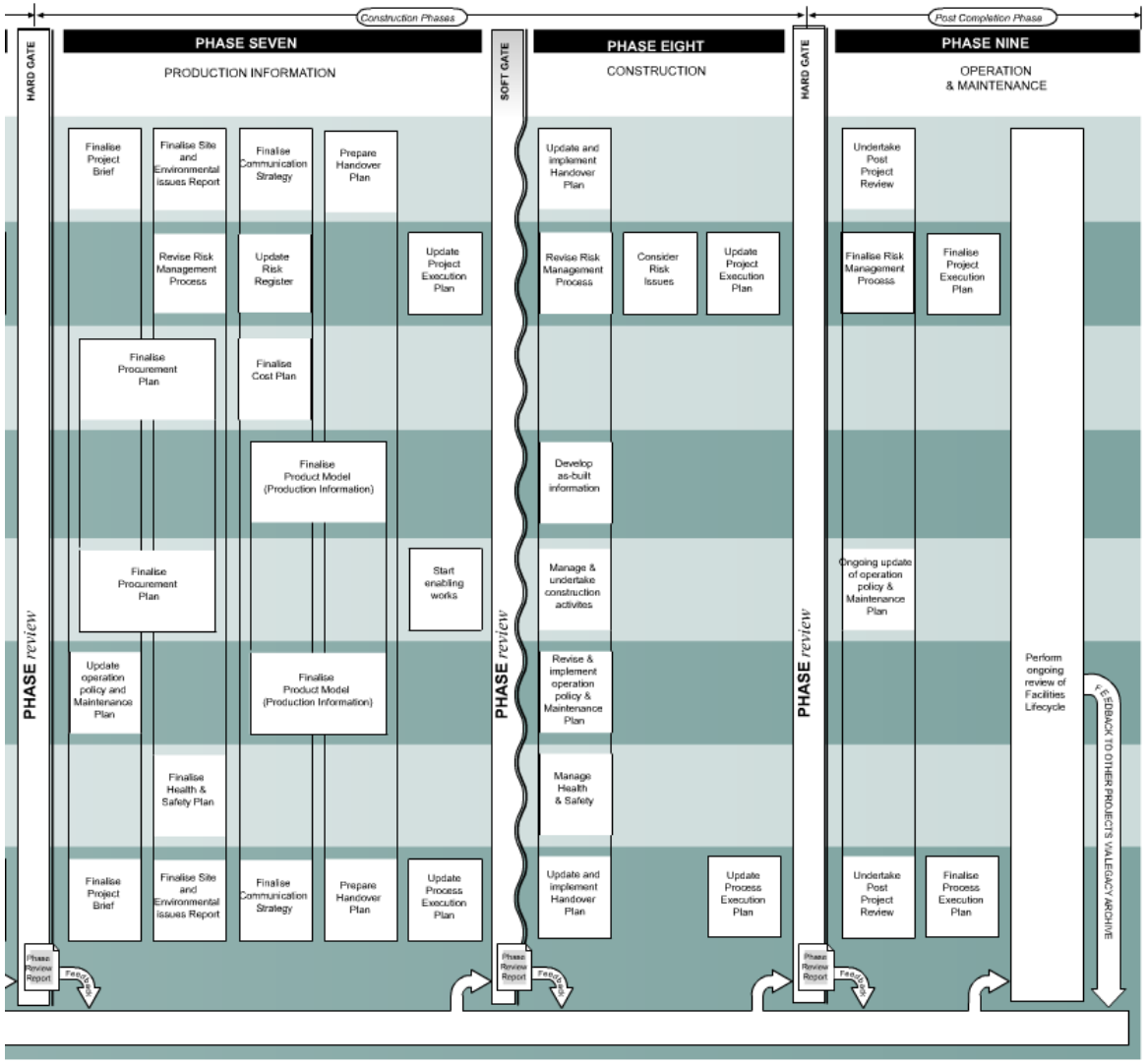


Figure 2.20: Construction Activity and Post-Construction in the Process Protocol (Salford University 2002)

The Activity zone of the PP contains the design process and it is represented by process owners, Process name, and participation from other activity zones in the process as shown in Figure 2.21.

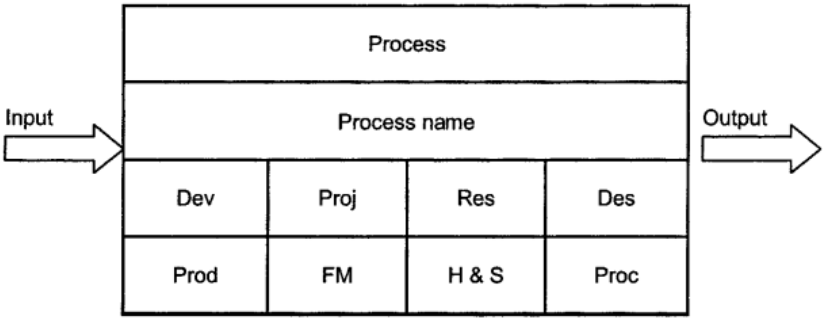


Figure 2.21:Process Symbol (Cooper et al. 2005)

The PP map as shown in Figure 2.22 contains three independent levels which there are no interactions between them. These levels are defined as following:

1- Level 1 contains the high-level process and the map shows the process deliverables

2- Level 2 contains the sub-processes of the main process which explains what the level 1 process consists of and the methodology of undertaken the level 1 processes.

3- Level 3 contains the sub-processes of the level 2 processes.

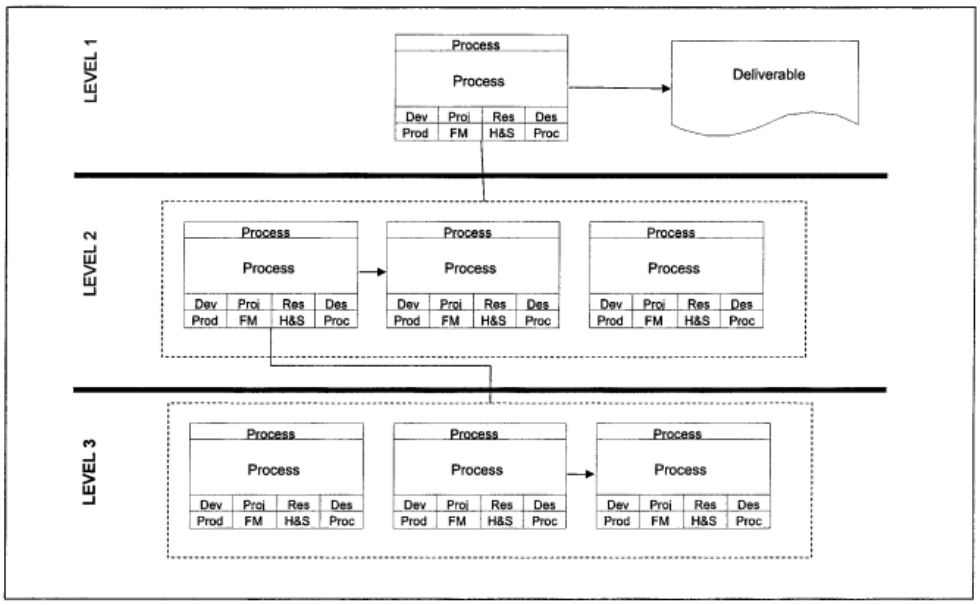


Figure 2.22: PP Process Levels. (Cooper et al. 2005)

Level 3 shows sometimes more than 1000 processes defined as explained by Cooper et al. (2005). Thus the model is aided by IT support tool that modification and adaption of the generic process to specific projects.

The IT tool (Figure 2.23) provides the following benefits as believed by Cooper et al. (2005)

- Knowledge capture functionalities: that includes drawing and documents produced to record the project activates based process creation tool.
- Knowledge development functionalities that analyse the information of the project in order to define the information pattern and potential conflict, besides defining the construction programme and construction process simulation for identifying possible break down.
- Knowledge sharing tool such as email notification and document sharing.
- Knowledge utilisation functions like interface with web and allow for personalised project information page for the users and powerful search tool for retrieving information and documents.

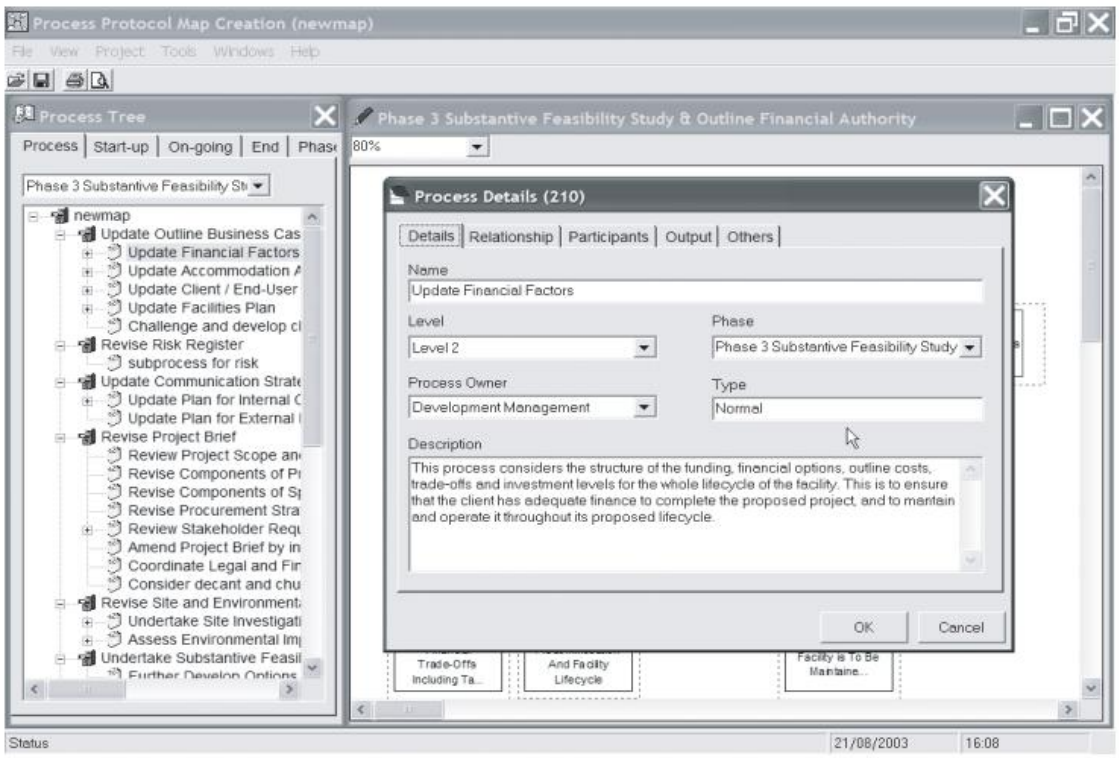


Figure 2.23: The IT Process Tool (Cooper et al. 2005)

The following Table 2.6 provides a comparison summary of ADePT and PP.

Process Protocol	ADePT
Provides generic view of the different design stage and it extended to the execution stage	Focuses in managing the detailed design process
Deals with the different disciplines through defined activity zones in each project stage	Propose decomposing the project according to each discipline specialty
Uses IDEF0 technique	Uses DFD's and IDEFv technique
Addresses the issue of stakeholder management at project initiation stage	Considers Stakeholder input as part of the information required to do the design task
Decomposes the project into different levels till reaching to the design task	Decomposes the project into different levels till reaching to the design task
Linked to IT software	Can be linked to IT software
Addresses the issue of contractor involvement in the design process	Not addressed
Facilitates the feedback principle and information management	It is used as a knowledge management tool
Provides an area for planning the project and design activity through the activity zones	Linked to a planning tool that provides adequate planning for the design process

Table 2.6: Comparision Summary of ADePT and PP

After exploring the design management models and techniques, the following will examine the sources of complexity in modern construction projects.

2.4. Design Process and Project Complexity

Eppinger et.all. (1991) explained how the effort of developing complex product remains a technical and organizational challenge. Therefore, the design process shall address these complexity issues in order to gain success. Complex projects require increased number of specialties within the project. Turner (1986) described how this will add considerable load on design managers in terms of

coordinating the efforts of different disciplines, communication and interfacing their input. Hence, it is required to have common tool which is easily readable between different disciplines. Moreover, communication and integration shall be monitored by design managers to assure that design dimension taken in any discipline is considered and implemented in the final design (for example electrical panels sizing and its affect on architectural layout and mechanical ventilation requirement). The involvement of this large number of designers in the same team also has an impact on the design process, information flow within the team and synchronizing the information between all members is crucial for the consistency of the design process. Therefore fulfilling what is the required information to feed design process and who is responsible for that shall be clearly monitor-able by all the team.

Complex construction buildings always have the aspect of interplay of their many components. Helbing and Lammer (2008) explained how it is well known that designing for whole is much more complex than the sum of the parts. The integrity of these components makes changing the individual component of design challenging work and sometimes it can cause a domino effect (cascading effect) which causes the collapsing of the complete design (Crabtree *et al.* 1993).

Complex projects suffer from the complexity of administrative procedures, documentation and legislation, as remarked by (Helbing and Lammer 2008). Regulating several design stages and documenting the design processes is essential for history tracking, control and recording the aspects affecting taking particular decision at particular time. Hence there is a need for integrating documentation in the design process to aid designers to overcome the bureaucratic difficulties of procedures. This might facilitate converting these procedures to become helping tools for achieving the design requirement (e.g. forms that takes stakeholders signature or agreement on particular design decision).

Gidadio (1996) explains that complexity in construction is characterized in the need of developing many details to reveal how to execute the work. Moreover, complexity needs a logical link as a complex projects always runs into a number of modification through the project construction and without studying the link between activities it becomes hard to update the programme successfully in the most competent way. Gidadio (1996) goes into more details and organizes the

source of complexity factors that affects the objectives of managers in construction into two groups:

Group A: that interacts with the inherent components in the operation of individual task and initiate from the environment or resources employed.

Group B: that handles the components originated from bringing different parts together to form a work flow.

The factors of project complexity are studied by Wood and Ashton (2010) and are presented as shown in Table 2.7.

Rank	*Main factors*	*Importance index*
1	*Organisational complexity*	*0.819*
2	*Uncertainty*	*0.733*
3	*Overlap of construction elements*	*0.675*
4	*Inherent complexity*	*0.644*
5	*Rigidity of sequence*	*0.600*
6	*Number of trades*	*0.488*

Table 2.7: Main Factors of Project Complexity (Wood and Ashton (2010)

Wood and Ashton (2010) conduct further analysis and identify 46 project complexity factors. These are categorized in five themes as following:

1- Organisational (people involved/relationships)
2- Operational and technological
3- Planning and management
4- Environmental
5- Uncertainty

The organisational theme of project complexity comes from the people involved in the project and the relation between different parties. Organizational complexity according to Wood and Ashton (2010) is made up of poor relationships between the project parties, having a large number of project stakeholders, problems with client, poorly defined project roles, poor communication and poor decision making.

The operational and technological theme is related to the building process, technology implemented, and inherent difficulty of the process itself.

Operational and technological theme is made up of factors related to high amount of mechanical and electrical installations such as high degree of technology, incorporating state of the art/leading edge or new technology, regulations to be adhered to, physical size, high degree of physically and technically complex roles.
The planning and management theme consists of factors related to the planning, rigidity of sequence and concurrency of a project, the theme is made up of factors such as large number of elements that make up a process, high level of interdependencies between processes, project coordination, organisational structure, long timescale projects and rigidity of sequence.
The Environmental theme includes the physical, social, legal and economic factors such as, sites in a restricted environment, public environment, market conditions, legal environment and international projects.
The Uncertainty theme consists of factors which are difficult to accurately predict such as the lack of uniformity due to continuous change in resources, mechanical, the effect of weather or climatic condition, undefined work in a defined new structure, undefined structure or poor build-ability assessment, uncertainty resulting from overlap between design and construction, lack of experienced local workforce.

Having explored the sources of complexity in modern construction, the following will explore the aspects of complexity in airport construction projects.

2.4.1. Airport Construction as Complex Projects

An airport is a very large and complex organization that can mirror the size of a small community when on site employees are counted. Airports are the providers of air transportation services to several local or global destinations to serve passenger and businesses needs. Schaar and Sherry (2010) explain that airports operate as utilities providing infrastructure to service providers and their supply chain under financial regulations. The duty of the service providers is to provide safe and secure service to the customers using the Airport. Schaar and Sherry (2010) further discussed that the challenge facing airport operators is building the Airport infrastructure, leasing it to the service providers, managing the service

providers to ensure that a quality service is delivered to customers, and ultimately supporting the growth of the regional economy.

Airports runs variety of activities such as passenger handling, ground handling and commercial activities. Airports might give the impression that they are managing only transport operations however the fact is that airports are considered as big real-estate investments and construction projects.

Adrem et al. (2006) investigated the characteristics that makes airport different from other construction projects and they found that these characteristics raises the construction costs from 15 to 25 percent higher than similar project done outside airport demises. One of these characters is the large number of different activities, Adrem et al. (2006) illustrated that several key functions need to be considered in the airport design process. Usually the specific project is owned by certain facilities management within the airport that is responsible for managing and developing all the airport's building and land. But for departments to execute the construction project it needs input from several key stakeholders in the organization all of whom want to optimize the design based on different aspects that are sometimes conflicting. Figure 2.24 shows an example provided by Adrem et al. (2006)

Function	Focus area	Example implications for construction project
Terminal coordination	Optimize the expected passenger flows	Area design that lets the passenger go from point A to B in the shortest amount of time
Commercial	Maximize commercial sales	Area design that forces the passenger to pass as many stores going from point A to B
Traffic coordination	Maximize flexibility to allow for different aircraft sizes and types of travelers	Complex flexible solutions driving costs
Customs/ security	Separate flows from Schengen/non-Schengen and arriving third country	Extra areas and separation needed for different type of passengers driving costs
Design	Maximize passenger experience	Complex technical solutions in order to achieve the extraordinary experience, driving costs

Figure 2.24:Examples of Airport General Construction Requirements

Security elements are one of the most obstacles facing airport project during construction. All personnel must obtain appropriate badges to enter the airport

airside zones. Moreover, working in live airport has its certain implications. Adrem et al. (2006) add more the issues of logistics inside the airport, driving vehicles, security checks for equipments, safety regulation, restricted working hours, work notification procedures, and many other construction factors which should be planned during design.

Adrem et al. (2006) revealed that when contractors become involved they have very limited freedom because almost all design elements are already fixed. Further detailed example of the airport project complexity will be discussed in the analysis of the case study. Moreover a detailed airport stakeholder analysis will be presented later in the research.

2.5. Design Process Model and Stakeholders Management

The construction industry has stakeholders just like other endeavours. The listed stakeholders in construction is long and includes (according to Newcombe 2003, and Smith & Love 2004) many entities such as the owners, users of facilities, project managers, designer, employees, subcontractors, customers, the natural environment.

Calvert (1995) divided stakeholder further into two categories:

– Internal stakeholders: who are identified as project coalition members or that are finance providers.

– External stakeholders: those are affected by the project in a significant way.

Ideal scenario in dealing with stakeholders is by minimizing their negative impact and maximizing the benefits they can provide to design. To achieve this equation it is required to recognize the power and interest of the involved stakeholders. A simple tool for mapping project stakeholders is presented in Figure 2.25. The difference in power between a firm and its associated stakeholders will provide the strategies and tactics for dealing with each other. (Chinyio and Olomolaiye 2010)

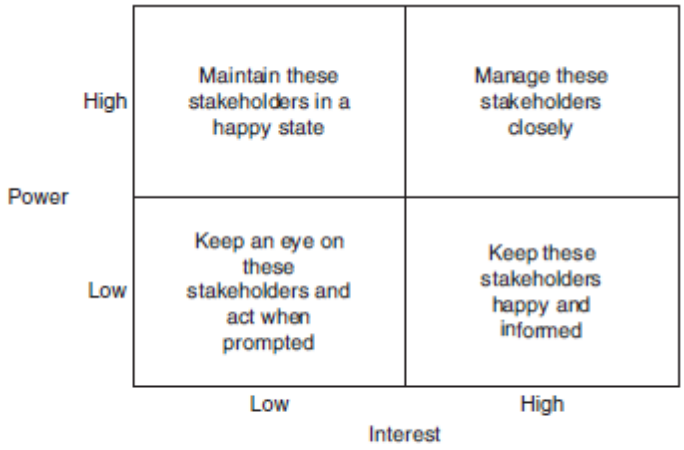


Figure 2.25: Stakeholder Mapping (Chinyio & Olomolaiye 2010)

Besides the power-interest dimension Newcombe (2003) also take in consideration a power-predictability matrix as shown in Figure 2.26. Therefore, organizations should have the ability to define those stakeholders that can make a surprise such as making a demand on or impose power in the project. The smooth progress of work in construction organization and stakeholders' interaction does not mean in necessary that a stakeholder might not act a sudden and unexpected requirement on the design. Therefore in ongoing projects organizations might provide a tolerance zone to make a performance band that can satisfy the interests of all its key stakeholder groups as illustrated by Doyle and Stern (2006). As projects might go out of this tolerance band, it is necessary to monitor their progress constantly.

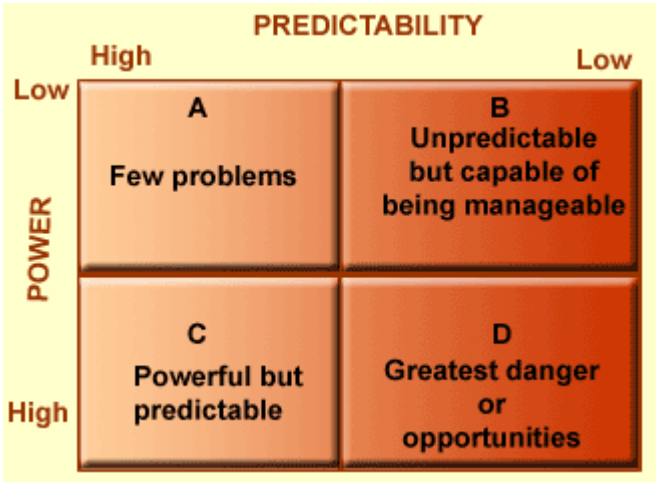


Figure 2.26: Power-Predictability Map (Newcombe 2003)

2.5.1. Need for Construction Stakeholder Management

Complex construction projects always engage multifarious clients, enormous project teams and long list of stakeholders where there is a serious need for efficient coordination and management of the different stakes and this demand effective leadership for the client. According to Latham (1994) and Egan (1998) this role of the client is usually underperformed. Stakeholder management improves capability in relational issues and reduces risks therein (Chinyio and Olomolaiye 2010).

Achieving a successful project requires design manager to adopt managing the multiple stakeholder interests throughout the complete process of project management (Sutterfi eld et al. 2006).

Weiss (2006) explains that the approach of stakeholder management considers many factors into account such as moral, political, technological and economic interests .According to Goodpaster (1991) there are three useful approaches for dealing with stakeholders:

1- Strategic approach: that allocates shareholders' profit a greater priority above the interests of other stakeholders.

2- Multi-fiduciary approach: that supposes a fiducially responsibility to stakeholders and assigning them equal stakes with other stakeholders.

3- Stakeholder synthesis approach: that assumes a moral but non-obligatory responsibility to stakeholders such dealing with them ethically.

For successful management of stakeholders in complex projects, Caroll and Buchholtz (2006) suggest key questions to be considered:

1. Who are our stakeholders?
2. What are their stakes?
3. What opportunities do they present?
4. What challenges or threats do they present?
5. What responsibilities do we have towards our stakeholders?
6. What strategies or actions should we use to engage our stakeholders?

The key principles in managing stakeholders are discussed by Clarkson (1995). He highlights the importance of acknowledge and actively monitor the stakeholders' interests and include them in decision making, also it is mentioned

how important is to listen and discuss with stakeholders about their concerns, predicted risks and contributions.

According to Clarkson (1995) it is required to have processes and modes of behaviour that are aware of the concerns and capabilities of the different stakeholder and recognize the interdependence of efforts and rewards among stakeholders, considering a fair allocation of the corporate benefits activity among them. Moreover, it is very important to acknowledge the potential conflict between the known roles as stakeholders and their legal and moral responsibility for their interests. This can be achieved through open communication and appropriate reporting incentive systems.

Bourne and Weaver (2010) introduced the "Stakeholder Circle" as a mapping framework to show data about stakeholders in reliable, staged and guided steps while presenting it in tables, graphs and pictures. The technique consists of five steps as shown in Figure 2.27:

1- Identify all stakeholders,

2- Prioritise them,

3- Display the current members of the stakeholder community,

4- Develop an engagement strategy and communication plan

5- Monitor the effectiveness of the communication.

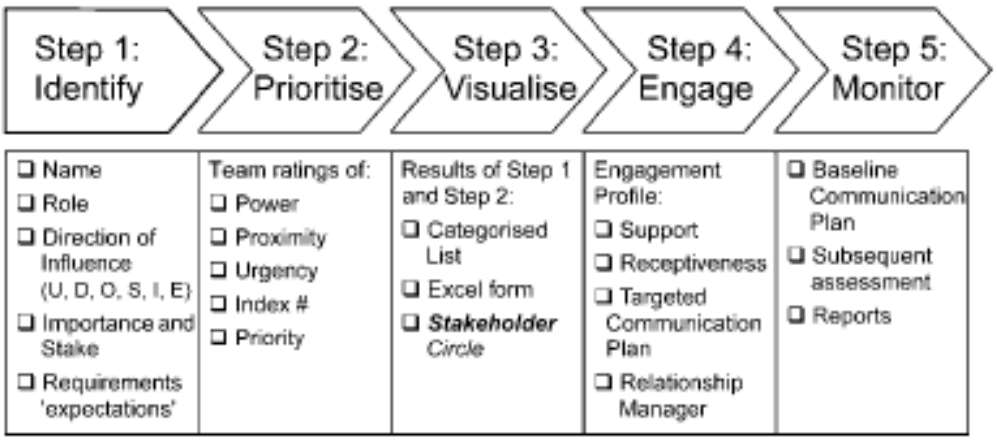


Figure 2.27: Summary of Stakeholder Circle Methodology (Bourne and Weaver 2010)

Stakeholder Circle technique is a helpful tool for designers to identify and priorities the key stakeholders in a project in order to develop a communication

plan that ensure understanding and managing the needs and expectations of stakeholders. The tool shows project's key stakeholders according to their influence on project's success or failure. This categorization ensures that the right stakeholder is targeted at the right time in the project.

In conclusion the stakeholders' aspects along with design management action are listed in Table 2.8.

Stakeholder management aspects to be considered	Design management action
Dealing with the unpredictable action of stakeholder	Identifying the stakeholders who has unpredictable action and provide a mechanism in dealing with them.
Dealing with moral, political, technological and economic interests	Consider these aspects during dealing with stakeholders and give attention to stakeholder power and interest matrix.
Stakeholder identification	Categorization of the stakeholders involved in the project and picking the appropriate stakeholder that can provide a decision about the project needs.
Stakeholder integration in design process	Identify the stakeholders role in the design process and recognize what specifically the design process demands from them
Stakeholders concerns and their predicted risks	Consider stakeholders areas of concerns and provide a mechanism for recording the former in the project history
Dealing with conflict between stakeholders roles and their interests	Find a balance between different stakeholder interests considering the power-interests matrix.

Table 2.8: Summary of Stakeholders' Management Aspects and Design Management Considerations

2.5.2. Airport Stakeholders Perspective

The nature of airport terminal stakeholders has significant influence on the design process due to the long list of these stakeholders and the variety of their requirement from the airport building. Schaar and Sherry (2010) classified and described the airport stakeholders and their goals at the Airport as shown in Table 2.9.

Stakeholder Group	Definition	The Stakeholder‘s Goals for the Airport
Passengers	Arrival, Departure and transferring passengers	- Move passengers quickly and conveniently - Ensure on-time performance - Provide access to low fares
Organizations	Organizations in region	- Maximize passenger and traffic volumes - Maximize number of destinations served and frequency of those services
Air carriers	Passenger and cargo carriers	- Ensure on-time performance - Ensure low cost of operations - Ensure safety of operations - Provide access to high yields
General aviation	Air taxi, corporate transportation, business aviation, etc.	- Serve as access point to the NAS through good availability and high equipment capability

Airport organization	Individual airports or multi-airport systems, including management and staff, with responsibility for building and operating the airport	- Achieve high security and safety - Grow revenue and manage costs - Drive economic growth - Grow passenger numbers - Find opportunities for new destinations and increase service frequency - Ensure sufficient (but not excessive) infrastructure capacity - Maximize non-aeronautical revenues - Maximize customer satisfaction - Achieve environmental sustainability - Minimize noise - Develop employees - Enhance competitive advantage
Investors and bond-holders	Individuals/organizations holding bonds, and the credit ratings agencies	- Optimize performance in factors under consideration (see section on investors and bond-holders)
Concessionaires	Operators of passenger services such as food and beverage and retail	- Maximize passenger volumes - Minimize fees paid
Service providers	Providers of services to air carriers, such as fuel	- Maximize traffic volumes - Minimize fees paid
Employees	Employees of the airport	- Provide secure jobs, wages, and benefits

	organization and airport tenants	
Federal government	Bill-payer for infrastructure (AIP), operator of air traffic control and security, and system regulator.	- Ensure that airports can accommodate growth - Keep airports up to standards - Ensure safety, security, and efficiency of operations
Local government	Local entities such as counties or cities which own airports.	- Maximize economic impact - Maximize number of destinations served and frequency of those services - Minimize noise and emissions
Communities affected by airport operations	Residents in region, and in particular residents near the airport	- Maximize economic impact - Maximize number of destinations served and frequency of those services - Minimize noise and emissions
NGOs, such as environ-mental bodies	Airport interest groups	- Varies depending on the interest group
Parking operators and ground transportation providers	Rail service, taxicabs, buses, shuttles, rental cars, limousines, and on and off airport parking services	- Maximize passenger volumes - Minimize fees paid
Airport suppliers	Suppliers of contractor and consulting	- Maximize traffic volumes

	services and equipment	

Table 2.9: Airport Stakeholders Goals (Schaar and Sherry 2010)

The list of stakeholder and their goals developed by Schaar and Sherry (2010) is used to generate a model that represents the financial, customer, and other relationships between airport stakeholders.

As Shown in Figure 2.28 the model consists of airport organization which consists of Airport Management and Operations and Airport Infrastructure. The service providers are the main entity that deals and interact with the airport infrastructure while passengers uses this infra structure to interact with service provider.

The model provides two outlines to the airport: Airport organizational boundary and airport service boundary, in addition to that, capital improvement bill payer-'s' boundary, local economy and community boundary.

Airport's organizational boundary defines the limit of what is controlled by airport management. This can control the design matters related to configuration of airport infrastructure and the operational procedures and efficiency of its own organization as explained by Schaar and Sherry (2010)

In contrast, it is observed that airport has limited control over the services provided as remarked by Schaar and Sherry (2010).This includes the volume and types of air service and the types and quality of airport concessions. By comparing this limited control with airport service boundary it is observed that the airport service boundary represents the service of the airport as a function irrespective of the organizational responsibility for provisioning that service. The stakeholders outside the organization judge the airport's performance from the airport service boundary point of view.

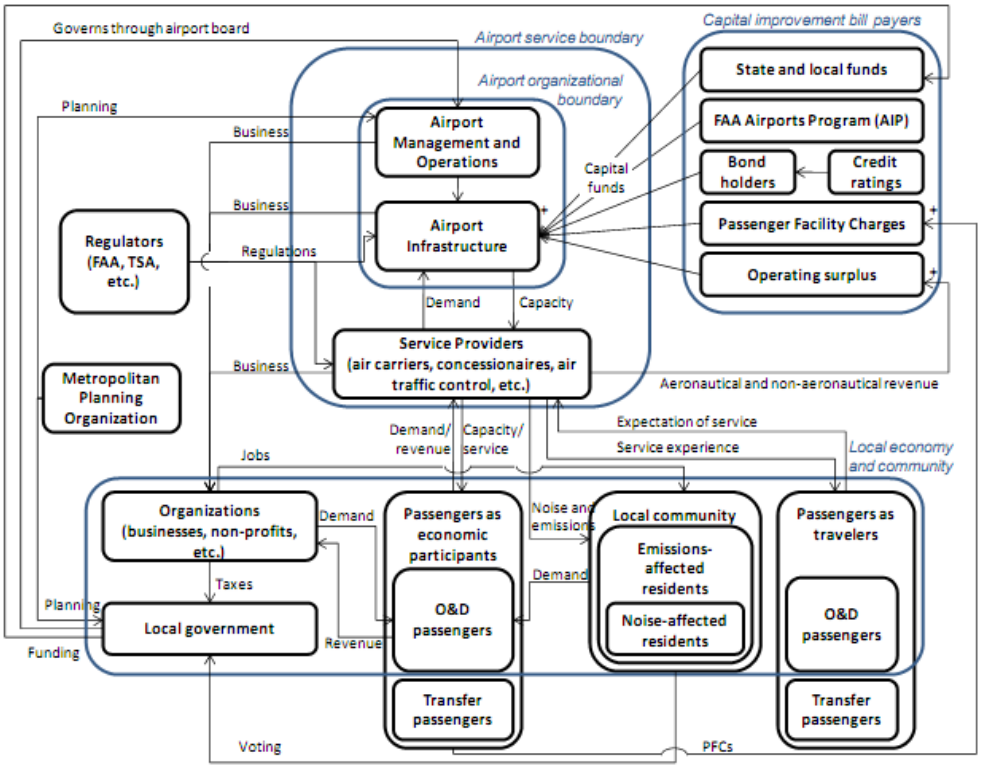


Figure 2.28: Relationships between Airport Stakeholders (Schaar & Sherry 2010)

This model represents the relationship between Airports stakeholders amidst a complicated network of business interests. This relationship might vary from one country to another .In some countries, airports are private sector while other countries airport is owned by the government. Therefore, the relationship might be changed subject to each case. Deeper analysis of this model might not be useful as the relationship between airport stakeholders is not the area of the research concern. The important to the research is the stakeholders who are going to interact with the design process and that will be discussed during analysing the case study.

This chapter has built the knowledge about design management models and techniques in manufacturing that found to be organized and detailed, and examined traditional construction design management models that found to be limited in modern construction. Advanced design management models in construction have been explored and the specification of these models has been defined in terms of dealing with design process in modern construction projects.

The complexity factors in modern construction are introduced, and more detailed analysis for the source of complexity in airport design has been presented. It has been highlighted that airports suffers from the number of building components beside the complexity in dealing with verity of stakeholders in the airport project. Stakeholders' management techniques have been examined and more detailed study for the complex network of stakeholders at the airport was introduced.

The developed knowledge from this chapter will allow providing in-depth analysis of the case study project in order to reach to the desired framework.

Chapter 3 : Research Methodology

After presenting the background of the research and developing an understanding about the design and stakeholders management in modern construction and specifically airport construction, the research is adopting the ADePT (Newton, 1995) and PP (Cooper et al. 2005) to achieve the aim of having generic design process and stakeholder management framework since they are providing advanced models for design management.

To explain more, PP has addressed the issue of providing generic view for the construction process and discussed the coordination levels between different disciplines which are highlighted as one of the problems in the research background. Moreover, PP has discussed the importance of dealing with stakeholders before initiating the project. ADePT has addressed the design hierarchy of the project in terms of dividing the project based on the involved discipline and highlighted how to coordinate between different disciplines. However unlike PP, ADePT has not revealed the different design stages of the project and it is more oriented towards discussing the details for managing the design tasks. Furthermore, it is not addressing in details the interaction of these stakeholders through the design process and construction process.

The aspects of complexity in modern construction are presented along with the aspects of Airports as complex construction projects and it became clear that there is a need to have generic framework for designers to handle the different aspects of complexity in modern construction. The complexity associated with the working environment and stakeholders of the airport is illustrated and it is found that the airport stakeholders' network is complicated and each stakeholder in that network has certain needs and objectives from the airport project which adds additional implication on designers in finding the balance between the stakeholders' requirements. Therefore there is a need to provide a framework for managing these stakeholders.

The next step in the research will try to answer the following questions:

How can the aspects of complexity in Airport Design be handled during the design process?

How can the Airport Stakeholders requirement and interests be managed during the design process?

How can Design Process and Stakeholder Management of Airport Projects construction being integrated in one model that aids designers in managing the complex airport design process and achieve the involved stakeholders' satisfaction?

Holt (1997) proposed a framework for research design as shown in Figure 3.1. This framework is adopted since it aids in developing a model that solves the presented problems in the research background. Based on that model, the existing knowledge in managing design and stakeholder is presented in the literature review as explained earlier along with focusing on the aspects of airports as complex construction projects and the associated stakeholders' network inside the airport. This literature helped in build the knowledge about design management, project complexity, stakeholder management, and airport construction projects aspects.

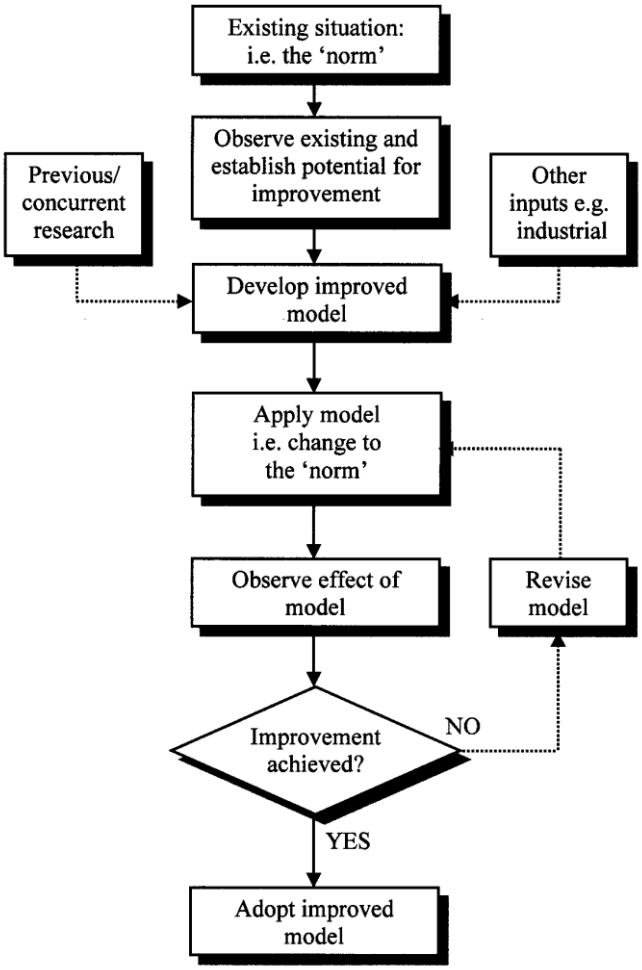


Figure 3.1:Applied Construction Research (Holt 1997)

The second step will be analyzing the current practices followed in Airport Construction. Therefore it is required to use the Case Study methodology to examine how the design of airports as complex projects is performed and how stakeholders' requirements are managed.

This is done through using the following principle of Triangulation in Case Study Research explained by Woodside (2010) as shown in Figure 3.2.

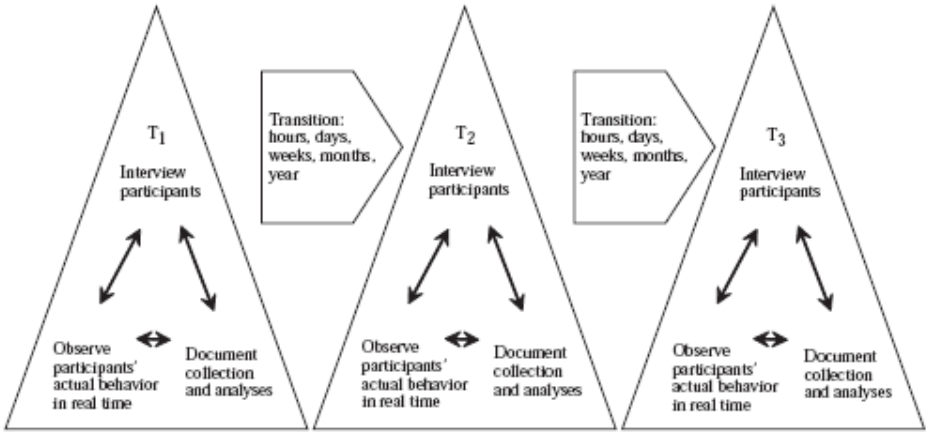


Figure 3.2: Triangulation in Case Study Research, (Woodside 2010)

This principle allowed revisiting the objectives and literature review, updating them, and revisiting the analysis of current practices based on the knowledge built.

The current practices analysis is conducted through examining existing practices followed in Airport design management by reviewing documents, interviews, and seeking opinions of professionals and practitioners involved in a newly completed passenger terminal project and currently working on existing expansion of the Aircraft Concourse project. These interviews produced narratives results, provided direct observations and allowed detailed document analyses. Later, these narratives are presented again to the interviews participants in the following time period to verify the narratives findings.

The case study methodology as Chetty (1996) explains is ideal for studying research topics where limitation in theories and applications exists. He adds more that it allows the firm to be views from multiple perspectives, through the

multiple-data collection which is interviews, observation and project document in this research. The Case Study methodology is supported by Cooper et al. (2005) and Newton (1995) as the best practice to develop design management models and the same principle is followed in developing ADePT, and PP. Chetty, S. Moreover, Woodside (2010) explained that case study analysis is important as it provides an opportunity for an in-depth analysis of current practices. The case of airport design is unique and requires from researcher to be fully aware about the project and its complication in order to provide accurate analysis for the current practices followed in the project.

One of the limitations of this research is the selection of one airport organization for analysis, the reason behind that is the small numbers of airports in the country besides the difference in the level of complexity between the case study project and other airports in the region. Furthermore, accessing the information of airport design in general is not an easy task for researchers due to the security revolving around the information related to such project. Therefore the involvement of the researcher in this case study helped in getting the information about the project with saving the privacy of the organization.

3.1. Case Study Brief:

The case study analysis is conducted in a Construction Authority (CA) in the UAE responsible for constructing and delivering one of the largest Airports in the Middle East. It is important to highlight that the factor of confidentiality is considered through not mentioning the project or organization's name beside the interviewed personnel's names due to some organizational consideration and based on ethical factors taken from Goodpaster (1991) such as, the special social interactions within organization, saving stakeholders right in not mentioning their names and, the organization right in not mentioning the name of the project or the name of the organization. The case study findings is taken from this organization experience and interviews conducted with staff working inside this organization, and consultants, contractors and suppliers who are working with this organization and having a wide experience worldwide in working in the construction of international airports. Moreover, stakeholders in that particular airport are interviewed and their feedback about the design process is considered.

Construction Authority role is combination of the municipality role in terms of giving approvals for the building inside airport demises besides the project management role in managing the airport construction project. The CA goes more in-depth in the details of design, procurement and implementation of the project. Moreover, CA is the government representative for project finance and payments.

The concept of CA is observed in many airports such as Doha Airport Expansion project. Nevertheless, it is noted that if CA does not exist in similar complex projects (e.g. Burj Khalifa in Dubai) a third party consultant will take the role of CA or separate project Management Company specialized in such type of projects as per Adrem et al. (2006) , and that is the case used in constructing France airports.

The project introduced in the case study analysis which is the Aircraft Concourse is an expansion of existing airport with a cost of one billion dollars. This project involves hundreds of contractors and sub-contractors besides several design packages as will be explained later in the case study analysis. The interviewees' are listed in Table 3.1 and they are chosen based on their responsibility in the case study and the CA organization.

Interviewee number	Position	Background	Responsibility
1	Chief Architect	Architecture	Responsible for the design management of the complete Aircraft Concourse from the consultant side.
2	Designer	Architecture	One of the consultant design team of the Case Study
3	Designer	Architecture	One of the consultant design team of the Case Study
4	Senior Design Coordinator	Architecture	The design coordinator of the consultant
5	Senior Architecture Manager	Architecture	The consultant site manager of the case study project.
6	Design Manager	Architecture	Specialist consultant in Airport retails
7	Design Manager	Architecture	Specialist Consultant in Airport Signage
8	Architecture Manager 1	Architect	The manager of the Aircraft Concourse project and some other projects in the CA
9	Architecture Manager 2	Architecture	Manages some running projects followed in the CA.

10	Senior Construction Manager	Civil	Manages the construction of the Aircraft Concourse in the CA
11	Senior Engineer	Civil	Following the project progress of Aircraft Concourse at site
12	Architect	Architecture	Working in the Case study project from the CA side.
13	Electrical Manager	Electrical Engineering	The CA manager of the electrical works in the case study.
14	Mechanical Manager	Mechanical Engineering	The CA manager of the mechanical works in the case study
15	Special Airport Systems Manager (SAS)	Electrical Engineering	The CA manager of the SAS work in the case study
16	IT Manager	IT Engineer	The CA manager of the IT work in the case study.
17	Senior Architect 2	Architecture	Coordinating Packages in the Case Study
18	Procurement Manager	Procurement	CA Contract Manager of the different packages in the case study.
19	Document Control Manager	Business Administration	Manager of Document control for different projects in the CA
20	Planning Manager	Civil	Planning different projects in the CA
21	Senior Development Manager	Airport Operation	Airport stakeholders requirement coordinator in the Case study
22	Development Manager	Airport Operation	Airport Stakeholders requirement coordinator
23	Operation Manager	Airport operation	Representative of the Local Airline carrier in the case study.
24	Cleaning Operation Manager	Airport operation	One of the stakeholders of the case study.
25	Construction Manager	Civil	Working in execution of the case study project from the contractor side
26	Supplier	Civil	One of the finishes package suppliers in the case study.

Table 3.1: The Interviewees' List and their Background and Responsibility in the Case Study

3.2. Interview Questions:

Based on the knowledge built in the literature review, the analysis of the case study is conducted through conducting series of questions developed in order to examine how the airport as complex project is handled in the Construction Authority.

The questions are categorized in the following sequence:

Complexity Management

Questions related to airport project design are developed to investigate how Aircraft Concourse Project complexity is handled. These questions are:

1. How does design management deals with the large number of airport building components?
2. How do you deal with different design packages interdependency?
3. What are the sources of complexity in managing airport design?
4. How the complexity sources are managed?

Design Process Management

This set of questions is developed to evaluate the method of handling the design process in the CA. The questions are

1. What is the framework of the design process?
2. How does the design process being managed between different departments?
3. How the design process being performed?
4. What are the procedures to get the building designed?
5. How the project data being collected?

Design and Organisational Structure

The next set of questions is developed to examine the organizational level of the design process followed in the CA. These questions are:

1. What is the role of each department in the CA?

2. How the department role is linked to the design process?
3. How does CA deals with the consultant and stakeholders?

Design Management Discipline

These questions will help indentifying the dimensions of the design management discipline in the CA. These questions are:

1. What is the role of design manager in the CA?
2. Is it limited to the design of the building components?
3. Does the design manager have other roles beyond the standard design tasks?

Stakeholder Management

The last set of questions is formed to test how the CA handles the management of the stakeholder in the airport project, these questions are:

1- Who are the Stakeholders in the case study?
2- How these stakeholders are managed?
3- What are the roles and responsibilities of different stakeholders in airport construction project?
4- Is there a standard for defining stakeholders' requirements?

The questions given are asked where applicable to the interviewee subject to his/her involvement in the project. The length of the interviews also varied according to the interviewee involvement in the project, the average of the interview time for design managers was around One and Half hour while the average of other disciplines was 45 minutes.

During discussing the answers of these questions, further ideas and examples have been raised and considered during the analysis.

Reviewing and analyzing the documents of the case study project helped in answering these questions. The accessibility to these documents is available through the direct involvement of the researchers in the project besides other documents describing the design process and the organizational structure of the Construction Authority. The results of examining these documents have been considered during the analysis.

3.3. Modeling Stage

Modeling methodology of Fellows and Liu (1997) is adopted as shown in Figure 3.3 to validate the model mentioned in the aim. This methodology suggests identifying the model objectives and analyzing the existing knowledge related to the objectives. Later, the model component can be identified allowing the model to be conceptualized and verified. Finally the model can be validated in order to be used to achieve the research objectives.

After establishing the objectives of this research, testing of the existing knowledge is done through the literature review. Defining what the model requires to address is conducted by analyzing the existing practices followed in the case study project. The verification stage is used to test the applicability of the advanced design management models in addressing the case study analysis observations and problems. The verification results showed limitation in these models however, the Process Protocol model addresses part of the desired model components. Therefore, it has been suggested to adopt the Process Protocol model with some modification to suit the research aim.

Later, the modified model is conceptualized with explaining how this model can address the issues discussed in the case study analysis along with suggesting a framework for managing the airport stakeholders during the design process.

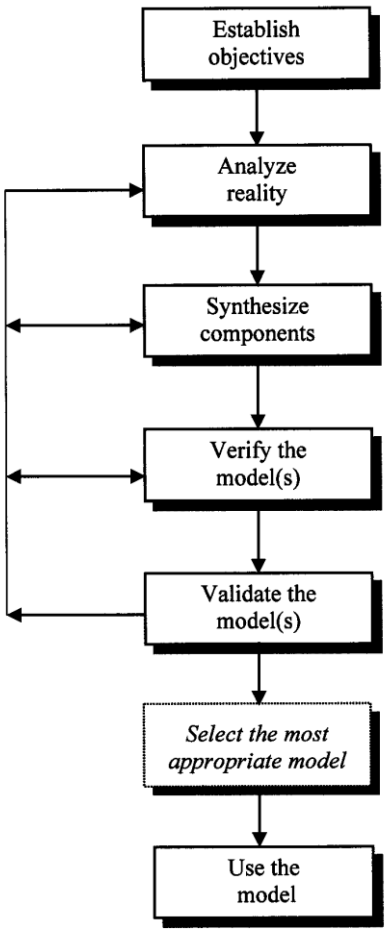


Figure 3.3: The Modeling Process (adopted from Fellows and Liu, 1997)

Model Validation

It has been found that the application of the conceptualized model is difficult to be implemented on real project since it needs long time observation and some organizational modification which is difficult to be imposed on an organization following certain rigid system. Therefore, an example is conducted for applying the proposed model on a virtual project in the Construction Organization as an ex-ante forecast according to Pindyck and Rubinfeld (1981) as shown in Figure 3.4 .
To address the issue of validating such model, it has been represented to key managers and employees in the Construction Authority and Project Consultant. The positions of these employees are as following:

1- VP Development and Master Planning
2- Chief of Architecture Department

3- Architecture Manager

4- Construction Manager

5- Specialist Advisor

6- Senior Architect

7- Senior Coordination Manager from the Consultant of the Case study project.

A group of three meetings is conducted with these interviews, the first group members are the Chief Architect, Senior Architect and Senior Coordination Manager, the second group members are the VP Development and Specialist Advisor, and the third group members are the Architecture Manager and Construction Manager. The purpose of these meetings is to explain the proposed model in details and get the feedback of these interviewees. Each meeting lasted for 3 hours and through that meeting, the application of the model and the example provided in this research was carried out. The feedback and comments was discussed to assess the validity of the model and suggest further improvement to adopt such model in future projects.

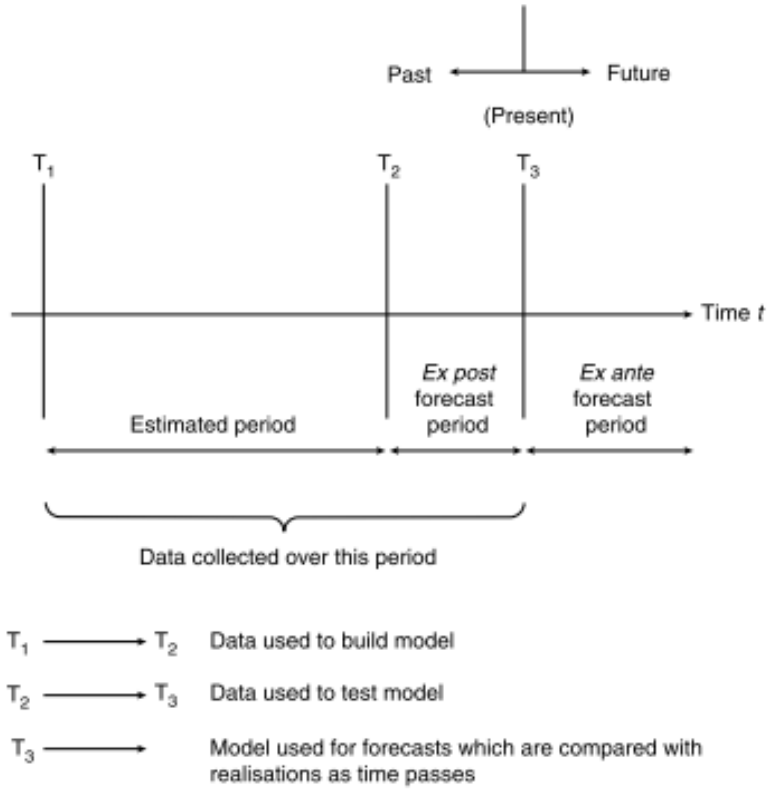


Figure 3.4: Data Collection (derived from Pindyck & Rubinfeld 1981)

Chapter 4 : Analysis of Existing Practices in Managing Airport Construction

This chapter explores the analysis of the interview answers and the reviewed documents. The findings of this chapter will help diagnose the problem faced during managing airport design and use the diagnose results in building the desired model.

4.1. Project Complexity Management

The CA as explained in the previous chapter handles large scaled construction projects such Airport Terminals, Cargo Terminals and Aircraft Concourses. The interviewees agreed that handling such building requires dividing the project into number of packages. An example of this dividing is shown in Figure 4.1 which is taken from constructing of the Aircraft Concourse project.

Through reviewing the Aircraft Concourse design documents, it is noted from Figure 4.1 that the project is divided according to the specialization. To explain more, there are specialized teams who are experts in handling each type of work. For example, Infra Structure Department is responsible for managing and supervising the construction of the work related to apron level such asphalting work, excavation, external MEP and Special Airport Systems (SAS) works. The Mechanical Managers highlighted that there is always close coordination between Infra Structure and other CA departments for solving the interface issues as they rise prior and during construction. Another example is given through reviewing the Finishes, MEP and Signage work package documents. The Chief Architect explained that this package is the largest one in the project and involves many sub contractors. Table 4.1 shows the size of this package through listing the subcontracts included beside the main work of MEP and SAS. In this package the design of the works mentioned in the subcontracts is done by the main consultant who has involved specialist consultants as necessary to develop the design of some of these packages such as Signage Package and Advertisement Package the Chief Architect explains.

Through exploring the division of the packages the designers interviewed explained that they are facing serious issues of coordination between different

components of the building as a result of the large number of building packages and different disciplines involved. One senior architect stated that beside the coordination load, there is the load of the complexity of the design elements itself. For example, handling the ironmongery design and review the contractor submittals of this item requires specialist engineer to be involved full time in designing and later reviewing contractor submittals because the door ironmongery configuration depends on the door function, location and international codes and regulation for life safety, beside the coordination with architectural function of the building.

Coming to the design management part, it is observed that the consultant appoints chief architecture manager to control the high levels of coordination between different building components, and when asking the design coordinator about the tools used for coordination, he explained that there is no special tools used, he added more that emails, minutes of meetings and flow charts are used to communicate the coordination between different disciplines and the coordinator is responsible for managing and maintaining these data which is not always an easy task.

It is important to notice that dividing the main project to packages is a mean to control the technical complexity issue highlighted in the literature review. Moreover, this division is done following the same principle presented in the ADePT model, however more sub-divisions are implemented in order to allocate the responsibility to different teams and reduce the load of technical implication associated with the project as a whole.

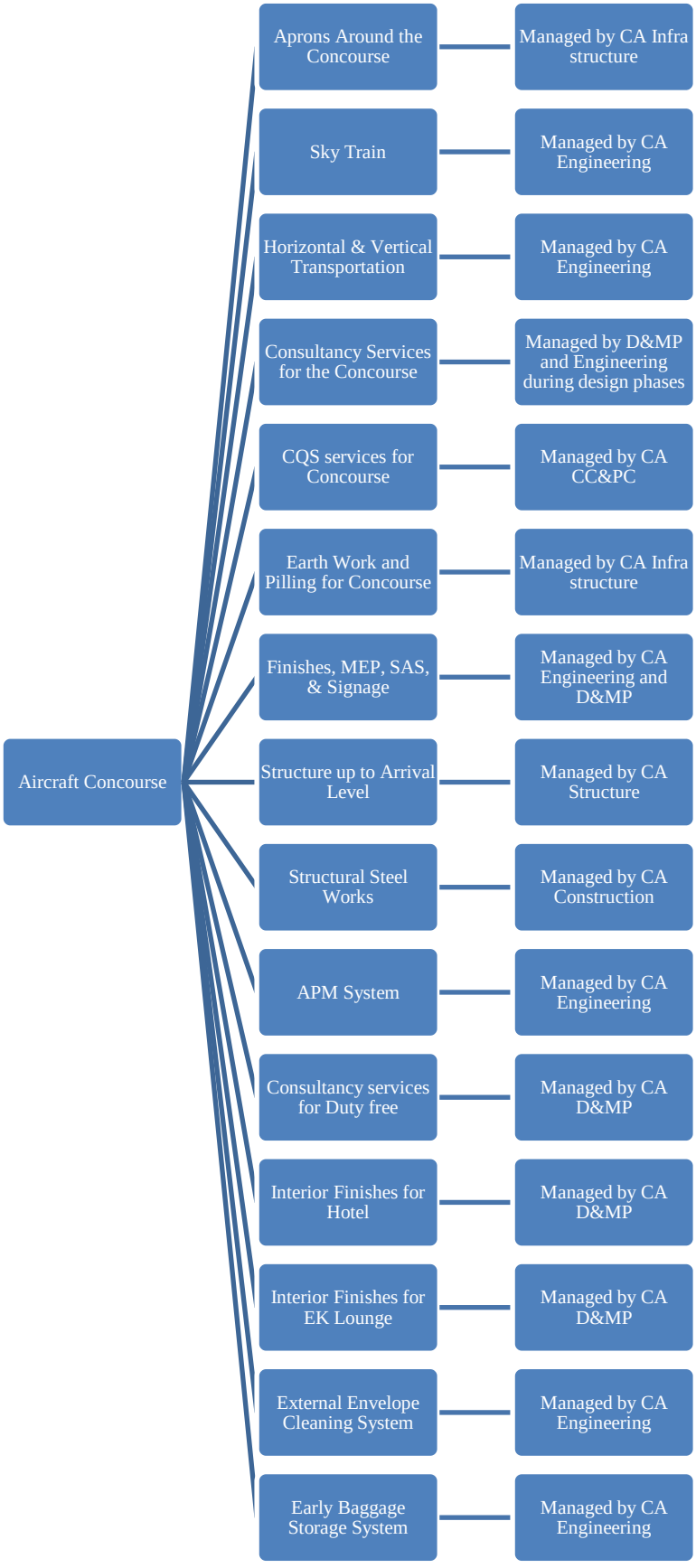


Figure 4.1: Aircraft Concourse Packages

Package Number	Package Description
1	Enabling Works
2	BWIC
3	Miscellaneous Metalwork
4	Waterproofing
5	Block work/Plaster/Screed
6	Marble, Granite and Stone
7	Rolling Shutters
8	Smoke curtains and Fire Barriers
9	Timber Doors
10	Cladding and Composite Panels
11	Ceramic / Porcelain Tiling
12	Bathroom and Toilet Accessories
13	Access panels and roof hatches
14	Steel Doors, Frames
15	Aluminium Doors and Frames
16	Drywall Partitions and Suspended Ceilings
17	Expansion joints
18	Painting / Wall and Floor Coatings (Specialist)
19	General Decorators
20	Signage Way finding and Advertising
21	Communication Kiosks and Search Booths
22	Raised Access Flooring
23	Carpets, Vinyl, Timber and PVC Flooring
24	Dock levellers
25	Interior Landscaping
26	S/S and Glass Balustrade
27	Glass Walls and Doors
28	Glass Features
29	Waterfall
30	Demountable Partitions and Toilet / Shower Cubicles

31	Vaulted Ceiling
32	Joinery Fittings
33	Composite Counters
34	Kerbs, Paving, Wheel-blocks, pre-cast elements, etc
35	Guard Rails and Protection guards
36	Control barriers, turnstiles, etc
37	Window Blinds
38	Water coolers
39	Lockers
40	Ironmongery
41	Fit Out (EK Lounges, Hotels)
42	Aircraft Stand Equipment
43	3rd Party Testing
44	Garbage Chutes
45	Lamp Posts
46	GRP Gratings
47	Water Features
48	Timber Cladding
49	Interior landscaping

Table 4.1: Subcontracts packages in MEP, Finishes, SAS and Signage Package

4.2. Design Process Management Analysis

While investigating the organizational part of the project design, the interviewees explained that there are process maps defined by the Quality Management Department that illustrate the interaction between different departments in the CA. These process maps show each stage of the project and the action required to be taken by each department. It has been found that these maps are applied for each design package shown Figure 4.1 separately (refer Appendix II). These maps divides the package into 5 stages taking the same principle followed in RIBA plan of work, these stages are:

A- Initiation Identification of project Concept Stage

B- Preliminary Stage

C- Draft Final Stage

D- Final Stage

E- Tendering Stage

One of the designers explained that it is practiced often for some packages to skip stage D (Draft Final Stage) and merge it with E (Final Stage). This merging is being done when accelerating the project design plan is required besides when the package complexity level accept having one final stage instead of two.

The organizational level for the design process involve Development and Master Planning (D&MP) department which has Architectural team responsible for monitoring and managing the design produced by the consultant. In addition to Engineering Department and that is divided into Electrical, Mechanical, IT, Special Airport Systems (SAS) and having similar function of the DMP in terms of MEP part. Moreover, there are Procurement and Commercial Department (PC & CC) and Document Control who are part of this process. With regards to Quantity Survey Company and Consultant, these two entities are involved as external parties in the CA organization.

The chief Architect explained that D&MP is responsible for managing different design stage activities (As suggested in RIBA plan of work). However, some projects are controlled by Engineering Department where the supply of the systems is the main function of the project. For example, the supply of new Baggage Handling System for an existing facility, the specialist unit, the Engineering Department leads the coordination of the design process.

When asking designers about the procedures or process of designing the building components, they explained that such procedure does not exist. One designer stated “I’ve got this job because I know how to design Airports”. One of the designers stated that by concluding the project requirement the project can be designed based on the designer experience, but he explained that there are no specific procedures for gathering project requirement. One designer explained that the traditional norm followed for determining such requirement is done through meetings between different parties, formal and informal discussions, emails, official letters and minutes of meeting, while design process is done through reflecting these recorded requirements in the design documents.

When asking about the role of Document control in the design process, the document control manager explained that this department role is to control the formal and official correspondence between Stakeholders, Designers and Construction Authority and End-users. Furthermore, this department does not interfere in recording the interaction inside the design process. Therefore, when arguments rise about a design detail happened in the past it is the designer responsibility to record and answer why it happened and based on what criteria it was conducted as there is no record for all the details in the document control department.

Based on the above it is concluded that the CA is following traditional design management model, which the literature proofs its limitation such as being generic, not providing enough details and being linear without flexibility between the stages. Moreover, detailed process of designing the different building component is not available and it is based on the employee's experience and self organization in recording the work he/she perform.

4.3. Design and Organisational Structure Analysis

The analysis of the interaction between the different departments in the CA organization showed that these departments are performing a collaborative work in matrix organization along with the consultant to achieve the deliverables of each phase. The reviewed organizational documents and process maps explain this statement in details:

A- Initiation Identification of project

This level shows a leading role for Development and Master Planning department (D&MP) or Engineering department where applicable in managing the process of identifying the project brief and guiding End-users for rationalizing and forming their needs and requirements. Workshop meetings, experiments and site visits are usually conducted between different departments and stakeholders to proof the project needs and requirements.

B- Concept Stage

Again D&MP plays the main role in ensuring that the concept is meeting all parties' expectation (Government, Stakeholders and Construction Authority). Engineering department performs important input for the services requirement, besides that PC & CC has an input in terms of monitoring the cost. Recently, the different departments in the CA performed initial value engineering as stated by the mechanical manager to assess the best solution to be adopted to address the end-user requirement and the results is presented to all stakeholders for taking decision, however this exercise is not reflected in the reviewed documents or procedures in the organization.

C- Preliminary Stage

The coordination of process between D&MP, Engineering and PC&CC increases dramatically in this level. At this stage the technical solution is discussed. Moreover, procurement and financial criteria begin to get shape. Stakeholders are involved at this stage through more detailed presentation about the stage. Besides they are required to sign off at the end of this stage.

D- Draft Final Stage

Similar to Preliminary Stage, the technical solution is formed and procurement method is determined and reviewed by D&MP, Engineering and PC&CC. The top management can get approximate idea about the project cost. Later, value engineering is conducted at this stage and documents are sent to the Stakeholders for signing off.

E-Final Stage

Procurement manger explained that PC&CC starts taking leading role at this stage since Quantity Surveyors are involved, more details are discussed and agreed before approving the design to proceed for tendering stage.

F-Tendering Stage

This stage is leaded by PC & CC as architectural manager explains. Documents are sent to D&MP, Engineering, and Consultant for information and the formers contributes in answering tendering queries. In both Final and Tender stages the documents are sent to Stakeholders for signing off.

Stakeholders in all stages are kept informed and involved in taking decisions as they arise through the design development. These decisions are documented as mentioned earlier through emails, letters, and minutes of meetings as Development Manager explains.

Analysis of the relation between Construction Authority and Consultants

This section explores the role of the CA in the design of the building component and examines the role of CA in monitoring the details of the design process.

The reviewed contractual agreement between CA and Consultant describes the deliverables required from the consultant, and summarizes these deliverables in three stages. The first stage is concept design stage that includes deliverables such collecting design data, producing design brief, producing preliminary design. The second stage is Final design that includes deliverables such as final drafts of Architectural and services, draft specification, and cost estimate. The last stage is tendering that includes deliverables such tender documents and specifications. Appendix (III) shows each stage deliverables in details.

The procurement manager explains that the contractual document shows a complete responsibility on the consultant in conducting the duration of design phases. However the Architecture Manager revealed that real application is not matching the contract documents. The CA departments go to the details in discussing the design process and design decisions taken besides monitoring the gathering of data and stakeholders requirement. The CVs of the CA employees shows experienced staff in designing and managing airport projects. The chief Architect explained that the detailed input of CA employees is required to monitor the consultant work and design. The reason behind that is Airports usually are outside the town municipality control because they are complicated projects and needs specialized staff to handle and approve such buildings. Moreover, CA is required to act as third party verifying the design and can tell the consultant that this design is accepted or not. On the other side, CA control is required to find the balance between the project stakeholder interests which will be explained more in details in this analysis.

The Architecture manager in the CA explained that in the history of the projects implemented by the CA, it is found that the organizational complexity of the project has increased significantly with the increase of the project complexity and the number of projects. Earlier, the consultant is used to control the complete process of the design when airport terminals were small in size and function. However, Modern airports imposed further dimensional levels on the design manager that will be discussed in the following.

4.4. Design Management Discipline Analysis

It is agreed through investigating the opinions of managers in D&MP department about the design managers' role in the organization that there are other dimensions in Airport design management the designer is responsible for. Figure 4.2 illustrates these concluded dimensions after the case study analysis and they are:

- End-User requirement management

One of the design coordinator stated "I have to contact number of end-users and convince them to accept the proposed design. At the end, one of them disapproves the design hence I have to repeat the cycle again" This dimension addresses the management of the nature of the end-users verity in airport projects and the airport operational development during design life span. Moreover, the changes resulted from variables such as new technology and change of operation techniques.

- Managing Multi-contractors (including main project contractor and design & Build contractors)

This deals as stated by one of the site architect with the implication of handling hundreds of contractors in terms of:

- Quality
- Technicality and Specialization
- Contractor Size
- Contractor Capability and proficiency

- Managing Multi-consultants

That considers the implication of dealing with specialized consultants and the issues of drawing integration and coordination between the sub consultant and main contractors.

- Managing airport strategic objectives in design

That deals with the impact of design life span on airport strategy due to the long time required designing such complicated projects and the need to revisit the design frequently in order to align it with airport strategy.

- Managing design changes during design duration (such as mock ups, design growth and development)

This part deals with handling design changes resulted from mock-ups and changes of requirement during design and the impact on the ongoing construction at site.

- Managing contractual relation and procurement

This part handles the relation between procurement and design. Moreover decides the procurement method and tries to agree on optimal approach to reach technical and financial solution.

- Airport Portfolio Management

This part tries to keep the project aligned with other projects in the portfolio of the airport in one hand, and future strategic projects in the other hand.

- Planning and resources management of design

That decides the project plan, duties and resources allocation of the involved parties.

- Managing multiculturalism of involved parties

This dimension manages the cultural variety of the involved parties of such international project and the impact of people attitude and perception towards the project.

- Design Value Engineering

That deals with the needs of revisiting the design packages frequently for design optimization and money saving

- Drawing Management.

This part handles issues such drawing accuracy drawing integration, detailed drawings, and software integration issues.

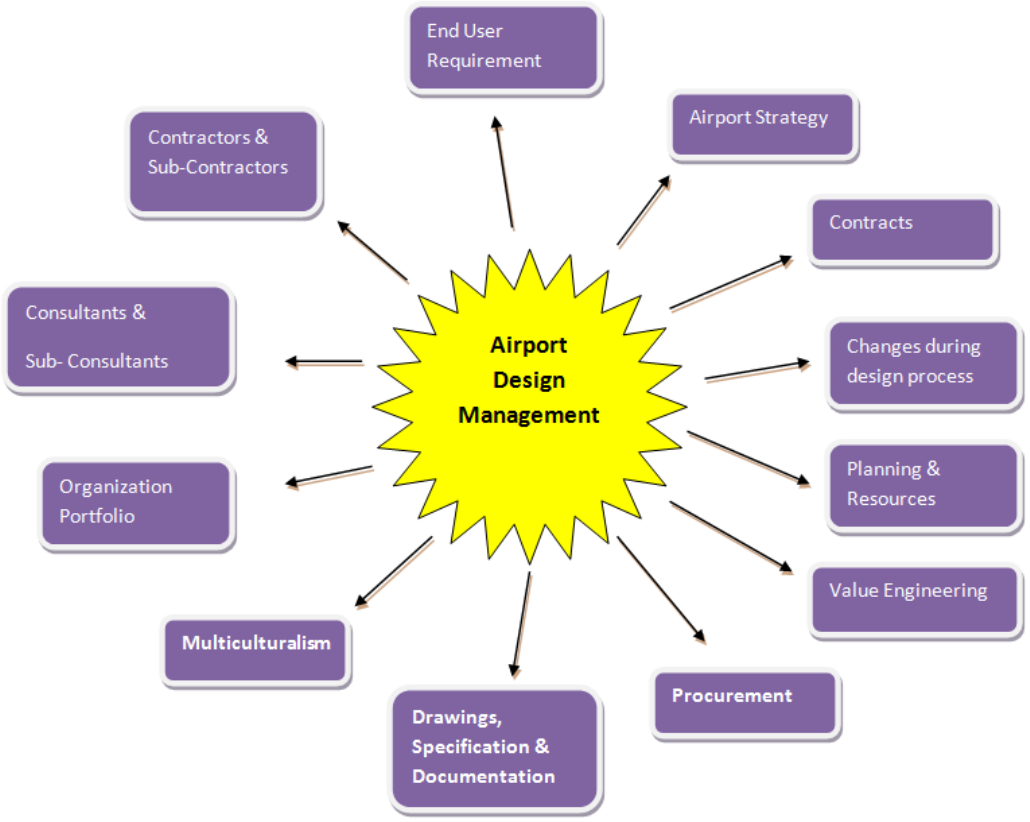


Figure 4.2:Airport Design Management Dimensions

These dimensions are very important when having massive complex building like the case study project especially when this building is part of strategic plan of the main airport project such as future expansions and additional supporting buildings. The design management discipline working in CA will have to monitor and coordinate these dimensions in order to make sure that the project is meeting the planned objectives from one side, and the project is aligned with the other strategic projects in the Airport portfolio from the other side, in other words, these dimensions add the responsibly of portfolio management to the DM. With reference to the earlier explanation about the consultant role in the design process, it is noted that the consultant focuses on implementing the detailed work of the design stage and address the design requirement on the design document of the stage, while CA is responsible for providing accurate information about these requirements through having more generic view of the project and the

organization from one side, and making sure that these requirements are implemented from the other side.

These explained dimensions are not only the responsibility of D&MP as stated by the SAS manager, other parties in the design process are also involved in taking decisions related to these dimension such Engineering and Construction departments. Since this research is limited to focus on the design process and stakeholder management, the other dimensions of design management are suggested for further research as such variables might have impact on several organizational levels.

4.5. Stakeholders Management Analysis

This part examines in details how CA deals with airport stakeholders, and what are the problems facing designers in managing their requirement during design phases.

4.5.1. Airport Stakeholders in the Case Study

By reference to the airport stakeholder model of Schaar and Sherry (2010) and examining the stakeholders in the case study, two types of stakeholders are marked interacting with design process of the Aircraft Concourse project. The first one is the Airport management and operation stakeholders, and the second one is services providers.

As suggested by Schaar and Sherry (2010), the Architecture managers confirmed that service providers are not always independent organizations and they might be internal stakeholders working under the airport management and operation. In this case study, one of the airport operation managers explained that the following service providers are managed by the airport organization:

- Cleaning services.
- Information services
- Supervisory and administrative duties
- Retails and food outlets

While a separate Agency “managed by airport organization” is handling the following services:

- Baggage handling and sorting
- Loading and unloading of aircraft
- Interior cleaning of aircraft
- Passenger transportation from stands to aircraft
- Aircraft starting, marshalling, and parking

The federal governmental entities is managed by the airport organization and consists of the following departments

- Police
- Customs
- Immigration

The Aircraft concourse is designed to cater for the local air carrier company. This company is responsible for the following services:

- Catering and catering transportation
- Passenger handling
- Lounges and stands operation

Other service providers are the duty free as separate entity beside Airport Hotel and its related restaurant. Later in Chapter 5 a map will be provided to describe the hierarchy of the stakeholders in the case study.

4.5.2. Managing the Airport Stakeholders

The Architecture Manager explained that CA used to coordinate directly with the Stakeholders of the Airport organization. However, through the organizational development of the airport new department has been created in the airport organization under the name of Airport Development Department (ADD). This department as explained by this manager along with CA representatives validates, rationalize, coordinate and implement the requirement of the facility end-users. Other service providers such local Airline carrier, Duty fee and Hotel Operation remains under the direct coordination with CA with considering ADD involvement in the coordination meeting and correspondence send between

different parties. Figure 4.3 reveals the practiced relation between stakeholders and design process in the case study project.

The interviewees and document analysis did not show a clear effort in identification of the project stakeholders nor a manual describing how to deal with them. Moreover, when asking the Design Manager about the tools or techniques used in stakeholder management it was clear that he has no idea about such techniques. He adds more "I know how to manage these stakeholders through my experience". The techniques explained in the literature might be implemented indirectly during dealing with the stakeholders such as considering stakeholders power and interests. However, there are no clear criteria about stakeholder management concept in the CA.

Through interviewing the design managers and stakeholders, it has been marked that the process of design management usually goes smoothly during design brief, concept design and preliminary design stage as explained by the Design Coordinator .The information in these stages are generally understandable by all involved stakeholders. However, things get more complicated during getting stakeholders approvals on draft final, final and tender documents. The Senior Architect explains that the load of information and details in the drawing becomes massive and the stakeholders who are not specialized in technical part of the construction process faces difficulties in dealing with the information load.

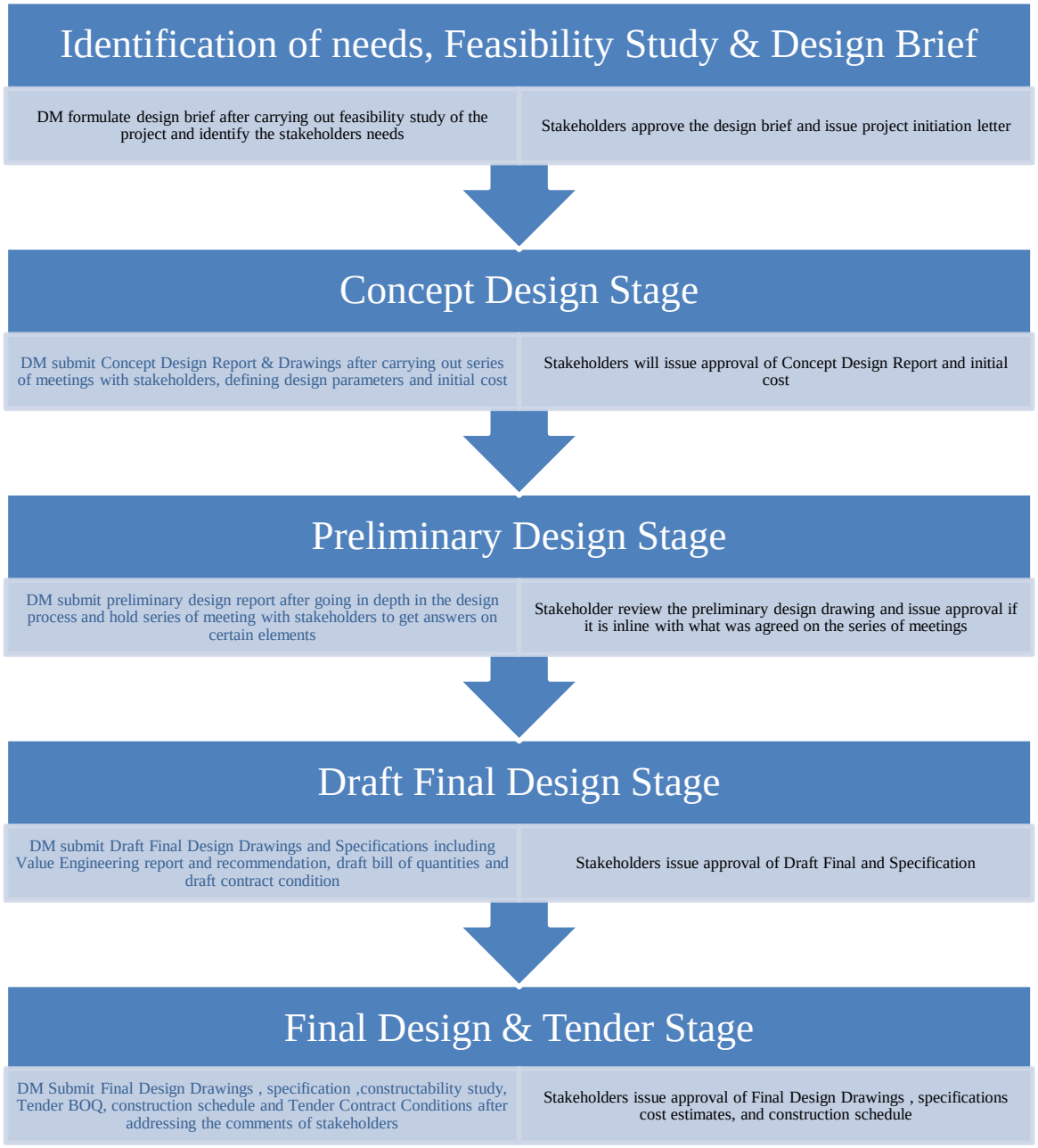


Figure 4.3: Current Design Process and Stakeholder Interaction Diagram

4.5.3. Approval of the Design Phases

While exploring how the approvals on different design stages are got, The Design Coordinator explained that there are formal correspondences in approving each stage by documenting the comments on the submission. However, the design process requires frequent meetings and discussions of design details with stakeholders. The documentation involved in recording the design details that should be done through official transmittals usually take from 3-6 weeks to be

circulated between the involved parties in the design process as explained by the Document Control Manager, while important decisions are required to be taken in specific time as explained by the Architect. Hence, it is practiced to record these agreements through minutes of progress meetings, emails and formal discussion for data collection of the requirements.

Senior Architect noted that during concept and preliminary design stage those end-users used to exaggerate their requirement. For example when designer ask the end-user about the office space required to run certain activity inside the airport, the end-user will end up with a list of rooms and areas which are not necessarily required. Moreover, operation process could be achieved without constructing such facility from designer point of view. The ADD Manager point of view is that designers are not aware fully about the operational requirement and these spaces might be required for future expansions or additional requirement for that particular operation process.

This case showed that there is always a conflict of interests between the parties involved in the design process. The Architecture Manager explained that the CA as government representative tends to reduce the built up area and save the money of unnecessary requirements, while the end-user needs to get the extreme end of requirement to run the operational needs in smoother manner.

4.5.4. Design Reference and Criteria

While exploring the reference of designers during conducting the design, the Chief Architect explained that there are standards that aid airport designers in defining spaces and requirements however these standards are not always enough. The Architecture Manager explained that standards such as IATA regulation in designing airports helps in aiding designers in defining space and operational requirement for some part of the airport facility. For example, the number of immigration counters required at the arrival lounge for processing passengers. However establishing such criteria in other parts of the building like the design of toilets in the public area does not match the standards recommendations. The Manager explains that It was required to monitor the toilets in the existing facility in order to be able to establish the correct design criteria as the international standard does not consider factors such the toilet location inside the airport that add load on the toilets in that particular area. For example, the arrival level

requires more toilets number than the baggage claim area as the passengers coming from the aircraft needs this facility immediately after arriving. Furthermore other criteria has such impact like using the urinals helps in reducing the number of toilet cubicles in Europe but it does not do the same in the middle east for some cultural reasons and habits.

In addition to the above one of the Senior Architects explained that the life cycle of the airport project is longer than traditional construction projects. Hence authority used to be changed several times during the design live cycle and whenever new authority comes, the requirement changes. Additionally, the rapid development of airport systems and the security needs usually demand a revision to the approved design principles and that always used to affect the design process due to the represented changes.

It is noted through interviewing CA and Airport interviewees that although all the documentation processes are followed, it is always an area of argument between design managers and stakeholders that what is delivered on site is different than what is agreed during the meetings and it usually takes lots of efforts from all parties to study the history and proof that is right or wrong. To add more, designers might do some modification during workshop drawings or solve construction problems at site and this is not necessary being communicated with the stakeholders.

Way Finding Project Case Study

An example of problem faced during way-finding approval is summarized in the Table 4.2:

Task :Approving Signage location	Comments	Stakeholder interaction
Specialist consultant (SC) submitted design terminology (Design Brief)	The consultant addressed the current problems of existing signage and explained how to deal with the problem in the Aircraft concourse project	Stakeholders gave approval on the design terminology

SC submitted preliminary design	Stakeholders agreed on the principle used to address the signage problems, such colors, messages length, installation details, terminology of positioning … etc	Stakeholders issued approval
SC submitted Draft Final	The Stakeholder could not give decision on time to approve the detailed distribution of the signs and sign messages due to the technical details of the drawings and the need to involve several parties from the stakeholders committee who have operational tasks and cannot spare time to such long process.	Stakeholder failed to approve the drawing on time, and asked for series of workshop meetings to understand the terminology of positioning each sign which affected the work progress and added additional cost to the project

Table 4.2: Summary of Way Finding Case Study

As the table explains the design of this particular signage package was not approved. However CA approved the signage location to proceed for construction and postponed the signs messages approval to later stage when all parties can think more of it. It is observed that such action has drawback like some modification might be required later on site to adjust the sings location based on the approved messages, but holding the package more will delay other packages such MEP works. It is noted that such decisions are usually taken to give more flexibility to design stage, Moreover, this practice is always required since there are many packages running simultaneously and the delay of one package will have successive impact on the other packages progress.

The interviewees in the CA agree on the existence of duplicated efforts in reviewing the drawings since CA has specialized employees in Airport Design. Involving stakeholders to that level of detail requires more employees in ADD

and needs to spare more working hours in reviewing documents they are not familiar with such as technical detail and specification. Airport Stakeholder point of view in this case is that ensuring signs location accuracy is important for them in order to ensure that correct messages are addressed in the correct position as they are more expert than designers in operation domain. Moreover, it is stated that current installation in the existing facilities continue to attract adverse criticism from passengers and it is required to establish a new benchmark in best practice and service standards for way finding. Hence, the specialist consultant has to prepare detailed messages presentation which extended the final design life span, and ended up in ADD not approving the submission.

Post project stage observation

The quick design approval, lack of adequate design guideline and the stakeholders' interests conflict is always resulting in that the end-users modifying the facility after handing over as explained by D&MP employees. ADD manager explained that in his experience many airports introduce design modification to increase revenue through increasing retail space or adding more advertisement. This increment will come on the account of the least powerful stakeholder like passengers the Architecture manager explains. The reduction of the area serving the passenger will impact the level of service moreover, this balance is always studied during defining the design criteria of each space and the facility user does not consider the generic view of the airport during conduction such modification.

Discussion

The previous analysis shows that design process followed in the Construction Authority suffers from the following gaps that all interviewees agreed on:

- The process does not involve the CA Construction department in the design process nor other contractors or suppliers. Several incidents showed that the involvement of these parties is required and hence they were involved informally in the design process through the relation of designers with the suppliers. It is noted that the involvement of these suppliers has implications as it might be understood as an advantage in awarding the job later and will prevent other contractors to bid for the project as explained by the procurement manager.

- Document control part is only limited to the formal correspondence while most of the dispute or arguments happens in the informal correspondence. Moreover, it is agreed during interviews that using emails and minutes of meetings have its limitation in terms of retrieving the data from the archive.
- It is noted that there is no description for the processes taking place inside D&MP department and consultant. To explain more, interviewed managers could not show a clear description of how the design of a particular part of the building is executed nor manual to handle the different parts of the design components .Although the correspondence such as emails, design brief or minutes of meetings might describe what are the design consideration required to be addressed during the design of that part of the building, however retrieving back what decision was taken about that particular part is not an easy task. In conclusion the design process lack of clear updated manual or criteria for designing airport project elements.
- The role of each department is not defined clearly. Many of coordination tasks happen on many levels therefore there is overlap of responsibility in taking decision. One of the Architects give example of deciding the procurement method which is officially the role of procurement department while all other parties such Construction department, D&MP and Engineering have an input in such decision, and it is well known that such decision has great impact on the design process. Other example is the involvement of the D&MP and Engineering in dealing with issues raised at site during construction which is not described in the organization processes. It is concluded that the coordination between different departments and disciplines is executed but not identified.
- In terms of dealing with design phase flexibility, the implemented process shows sequential approach to the design process which means that each stage is rigid and its requirement shall be fulfilled before proceeding to the other stage. However the real practice is not like that as explained by the Architecture manager. It is noted that in most of the projects, CA tries to overcome this concept by issuing conditional approvals to make the stages flexible. In other words, they try to implement the overlapping stage gate concept and give the design process more flexibility. An example for signage design in the Aircraft Concourse will discuss this issue later in the research

- The design process does not reflect the sources of complexity required to be addressed in the design process such as detailed coordination process between disciplines, administrative procedures and documentation. Moreover, there is no clear description of such procedures in other documents.
- The process suffers from organizational complexity represented in the relation between involved parties, the number of stakeholders, and the complicated mechanism in decision making that needs input from many departments, this is observed in the time required to release official document as explained by design coordinator.
- The documents and manuals does not address the planning and management complexity such as handling the large number of elements in the project, handling the timeline of the project and managing the acceleration of the project (which is always the case).
- There is no guideline for defining the project requirement and design criteria at the project initial stage which is crucial point for project success as per the findings in the literature review and as explained by the Chief Architect.

To summarize the stakeholder management observed practice, the following points are listed:

- The understanding of stakeholder term used in the CA is referring to the End-users of the facility. However the generic view of stakeholder in Airport project will be the Government who are the investors, Facility end-users who are the operators of the airport, and CA who are responsible for managing the interest of both parties.
- There is no clear understanding of the Stakeholder Management concept such as clear identification about the airport stakeholders, and how to deal with these stakeholders in different levels.
- End-user approval of design is essential part in the design process. However the level of end-user interference in the design process sometimes does not help the smooth running of design process, moreover it is not clarified what the end-users are specifically approving.
- Establishing design criteria and end-users requirement is not given adequate attention at design brief and not organized, Airport design standards sometimes

are limited in establishing such criteria as the operational requirement might be changed between airports.

- Documenting the followed design criteria based on stakeholder decision is essential and is in the favor of all parties. However it is observed that there is limitation in the traditional implemented practices such minutes of meetings and emails.
- It is found that there is lack in conducting experiments and site surveys to define the exact operation requirement. Moreover, CA is not involved in observing such experiments which is required to convince the investors about the validation of requirement.
- Many design changes used to take place after handing over the facility and that affects the level of services the building designed for. Therefore, there is a need to extend the designer involvement after the facility handing over.

This chapter has examined the problems faced during managing the design of airport projects handled by the Construction Authority. The objectives of testing the information flow of the design process and the issues of managing the design of the airport as complex project is achieved through the analysis conducted in the case study. Moreover, the objective of exploring the stakeholders' involvement in the design process in airport design is achieved by explaining the interaction of the airport stakeholders with the design process. It has been found that there are problems faced in different levels such as organizational, knowledge management and stakeholders' management during managing the airport design. Hence there is a need to have a framework that solves the problems associated with the design of airport as a complex project from one side, and addresses the issues of managing airport's stakeholders and interfacing them with the design process from the other side. The following chapter will explore a suitable framework for design process and stakeholder management in airport construction.

Chapter 5 : Modelling Design Process and Stakeholder Management

This chapter will examine the suitability of the existing advanced design management frameworks in representing the design and stakeholder management in airport construction. This will be done through testing how these advanced models are dealing with the problems presented in the case study. Based on the test results, the framework of design process and stakeholders management can be conceptualized and proposed for application. Later an example of applying the proposed model will be presented and the validity of this model will be tested through seeking the opinions of the people involved in the case study.

5.1. Suitability of using advanced construction design models in the case study

Through studying the literature and the techniques used in managing the design it has been found that ADePT technique developed by Newton (1995) and the Process Protocol in design and construction developed by Cooper et al. (2005) are suitable models for evaluating the design and practice in the case study as will be explained in the following:

5.1.1. Verifying the application of ADePT Model in the case study

The modelling of the building design process followed in ADePT (Figure 2.18) has limitations when applied in complex projects such as the Airport Concourse example. As explained earlier, the ADePT propose dividing the Airport Concourse project into the different disciplines without dividing that building into sub-projects which is the practice followed in the case study (refer to Figure 4.1 for Aircraft Concourse packages). Dividing the project into the Architectural, Mechanical, Electrical, Structural and SAS which are the main streams in the project will result in massive load of design tasks which will be hardly controlled.

Applying ADePT on the sub projects level of Airport Concourse again is a hard task. The number of design tasks involved under each discipline is still massive in some of the packages. For example applying the DFD's or IDEF0v on the sub-

package of MEP, Finishes, SAS and Signage packages list for designers will be a nightmare at this level of the project.

Applying ADePT on the sub-packages level can be considered useful because at that level the information requirements of design task and producing design process model diagram is manageable.

The following study (Figure 5.1) shows an example of Design Process Model (DPM) hierarchy for retail fit-out project. Level 1 shows the grand project and how it is decomposed into six different design disciplines in level two.

These disciplines are Architecture, Mechanical, Electrical, Special airport systems, IT and Civil. Level 3 shows an example of Architecture components of the design process. This decomposing can be done according to individual disciplines' perception for the design process itself. In this example: the architecture scope is divided into false ceiling design, door design, flooring design, project specification, interface with main package, and joinery work details. In Level 3 it is notable that design approach can be reached in different manner. In other words, designer can divide the Architectural work according to his needs and experience. Each component in Level 3 will form sub-model for the design process in Level 4. The example given is door design which consists of ironmongery design, door frame design and main door design. It is noted that Level 4 and Level 5 convert design work into constituent design tasks and it is possible to divide the tasks into further levels subject to design complexity. It is remarkable that these design levels are common between PP & ADePT and in both models designers can define the design tasks and its dependency in order to complete that task.

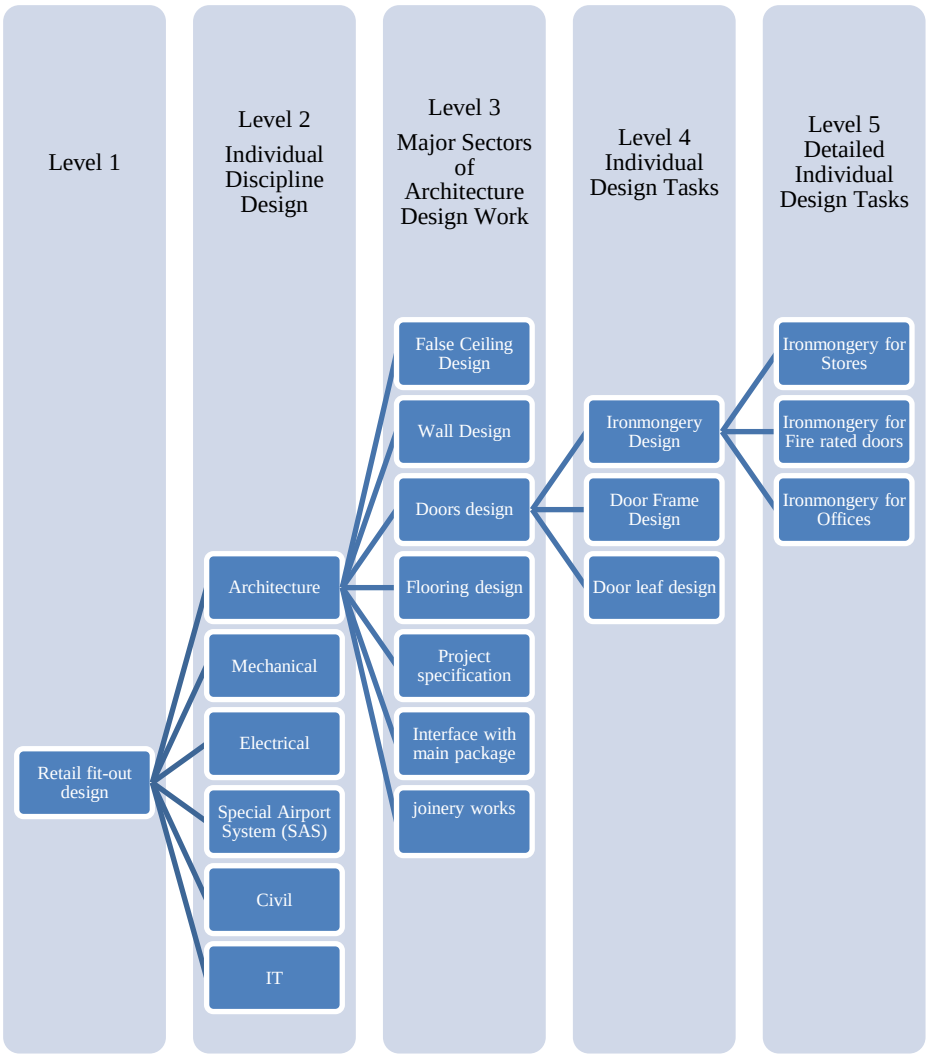


Figure 5.1: Example of Applying ADePT on One of the Airport Concourse Sub-Project Packages

This research faces limitation in applying ADePT in details to one of the Airport sub-project since applying this technique requires further studies to that sub-project in order to reach the design task level and define its dependency and links with other disciplines. An example of applying DFD technique is provided at the Appendix (IV) and taken from Newton (1995).

It is noted that the ADePT does not deal with the issue of stakeholders' management. Besides that it is not addressing the organizational framework of the complex project and the limitation in handling the sub-projects imbedded in the main project. Dealing with each design stage of the project is not discussed in ADePT and it is not designed to handle the complete project life cycle as will be presented in the Process Protocol model. However Austen et al. (1999) believes

that ADePT is not limited model. Therefore, the model might be developed to cover the discussed limitation.

5.1.2. Verifying the Process Protocol Model in representing the case study

By viewing the essential elements of the PP, it is observed that these elements are addressing the design requirement of complex project. The whole project view principle will promote the pre-construction activity and helps in identifying the client needs and design criteria. This principle also addresses the 'front-end' criteria which mean the involvement of contractors and suppliers in the design process. The consistent process principle aids in addressing the interface issues which the complex projects in general suffers from.

Progressive design fixity principle addresses the stage overlapping issue and how overcoming the design deficiencies resulted from project acceleration and the need to complete the package design simultaneously. The coordination principle is discussed in the process and change management activity zone where interfacing the different discipline is taking place. The PP model provides an area where Stakeholders can interact with designers in early stages to avoid change and production difficulties. Moreover, the Feedback principle is embedded in the process and aids in recording, updating and learning lessons from project experience.

The 10 stages followed in PP which is grouped in Pre-project stage, Pre-Construction stage, Construction stage and Post construction stages are advanced principle of RIBA plan of work and British Property Federation model which are followed in the discussed case study. However, PP is more advanced than these models as it is addressing the post construction stage which is one of the weakness area mentioned in the case study analysis.

By reviewing the PP model (refer to Figures 2.18, 2.19, 2.20) it is clear that the model provides advanced perspective for the complete complex construction project as whole. The introduced Development, Project, Design, Production, Facilities, Health and safety, Statutory and Legal, Process/Change Management is an advanced resemblance of the CA departments' interaction activities as explained in the case study analysis. Moreover, the knowledge management and

information archiving is provided by the PP through a link to IT software that eases the designers work.

It is observed that process level of PP model in the activity zones provide decomposition up to 3 levels similar to concept used in ADePT. Furthermore, more levels can be added as seen in ADePT model. Therefore the model helps addressing the issue of dealing with required levels of details. Additionally, the model provides software to achieve the task management.

The PP model has some limitations when applied to the case study. Firstly, addressing the building hierarchy in such a model might be risky. Merging all the sub-projects in early stages will be difficult since there are many disciplines and building elements involved in the project as whole as explained earlier. It might be viewed that close coordination between all disciplines is required in pre project and early design stages. Therefore, it is suggested that project segregation be applied after concept design stage where each discipline can follow more closely the details related to their field of specialization. This concept will be explained in detail later.

The end-user interaction is limited to the pre-project stage in PP model. The model assumes that end-users requirement are established and agreed (That is addressing the issue of establishing the design criteria discussed earlier in the case study analysis). However, end-user and stakeholder interaction is not extended to the other stages of the project as presented in the case study analysis.

PP assumes that there is “Facility Management” team who are responsible for ensuring the cost-efficient management of the building. This team consists of facilities management professionals, building maintenance professionals and representatives from design management. However, hiring facility and building management professionals to be part of the design process is not feasible as seen in the CA example. Therefore, there is gap between PP and the case study in dealing with the Facility management team role.

From the previous discussion about the applicability of PP model it is concluded that the model provides a solution for the generic frame work of the case study and it would represent a very useful tool in different levels such as the organizational, knowledge management and managing multidisciplinary from one side, and it provides an area for Stakeholders management integration within the design process. Moreover, it addresses the issue of managing design tasks.

5.2. Conceptualizing Design Process and Stakeholder management Model.

Since the Process Protocol is providing the most suitable model to represent the case study design process. Therefore the PP model is adopted considering the following additions and modifications.

Replacing Facility Management with Stakeholder Management activity zone:

Having facility and operation managers within the design process is very costly to the CA. An experienced airport facility manager will add unnecessary cost to the project taking into consideration that in airport projects, each facility manager has a point of view in managing the facility and defining the requirement (This is always faced during dealing with different stakeholders in CA). Therefore, revisiting the end-user of the facility is always required. Based on that, it is proposed to replace facility management zone with Stakeholders management zone which will be responsible for the following scope of work.

Ensure the cost-efficient management of the facility assets, and always revisit the primary objectives of the building owner and users. This scope might be extended to visit the Generic objective of the project in the Portfolio of the Airport projects as discussed earlier in the design manager tasks (Figure 4.2). The activity of this zone will work closely with the Development management and Design management activity zones, and can act as the contact point between stakeholders and design process.

The tasks related to stakeholder given to Development Management zone as explained by Cooper et al. (2005) will be given to Stakeholder Management zone which will extend the stakeholders coordination through the project life cycle (not limited only to the pre-project stage). By doing so, the Development Management can concentrate in dealing with strategic construction issues such CA projects portfolio management.

Considering Detailed design process

It is proposed that while a designer is working at the task level of the design process, he/she will visit the master list of stakeholders and address the stakeholders affected by his/her design decision as illustrated in (Figure 5.2).

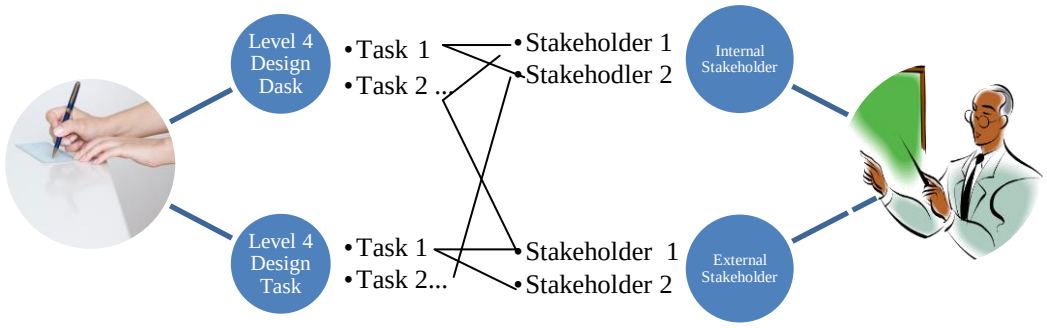


Figure 5.2: Stakeholder Interaction with the Design Process

While a designer is working on the detailed task level he/she will come up with issues not addressed in the design criteria or design guideline. Therefore, the designer will update the design criteria which will contribute in building the design manual of that part of the project the designer working on. The later designer can send the proposed decisions to the stakeholder managers whom will coordinate the approval of these changes. The task of preparing the list and getting stakeholder approval is collaborative work between Design management and Stakeholder management zones.

It should be considered that the approval on design decision is judged by balancing the point of view of all involved parties. For instance, defining the office space of one of the end-users is not subject to the end-user requirement. Other stakeholders will interfere in such decision such as CA who are keen about project budget and Airport Development Department (ADD) who are interested in finding the balance between different department requirements beside other design stakeholder such MEP who will have their input in terms of space allocation and technical requirement.

Once the design decision approved it will be documented in the IT software and added to the design criteria which will be used for similar future projects.

Addressing the Multi sub-projects issues

PP will be considered for each sub-project at the airport terminal to avoid the complication of mixing different disciplines works from technical and procurement point of view. This segregation can take place at Phase 4(Outline Conceptual Design) as shown in Figure 5.3 (which is the first phase of pre-construction stage). It might be argued that this segregation will result in

multiplying the teams allocated for each activity zone which might be valid from disciplinary level point of view. In other words, it is true that separate team will be allocated for Infra-Structure project, Structure Projects, MEP and Architecture Projects, however, each discipline will be cross functionally involved where his input is required. Moreover, the same team will be following multi projects under his discipline, for example same structure team will follow the Structural Steel works, Concert works and sub structure works.

It is clear that this segregation will introduce an organizational implicational since the involved employees will be working in a Matrix Organization where each employee is a member in many projects. In this case study this problem is dealt by each unit vice president (VP) who will determine the priority of the project that the employee is working on beside many other consideration which is not in the scope of this research. However, it is a potential area for further research. It should be considered that existing CA organization has Matrix nature, but by applying PP model, the organizational complexity might increase.

It is noted through the interviews and case study analysis that the PP shall have a Handing over Stage in Post-construction activities. This stage is very important in airport construction since there is a period of time (varies depending on the project for example Baggage handling system operation) for familiarizing the operational end-user with the systems installed. This zone is introduced in the model but it is not discussed in depth since it is outside the scope of this research.

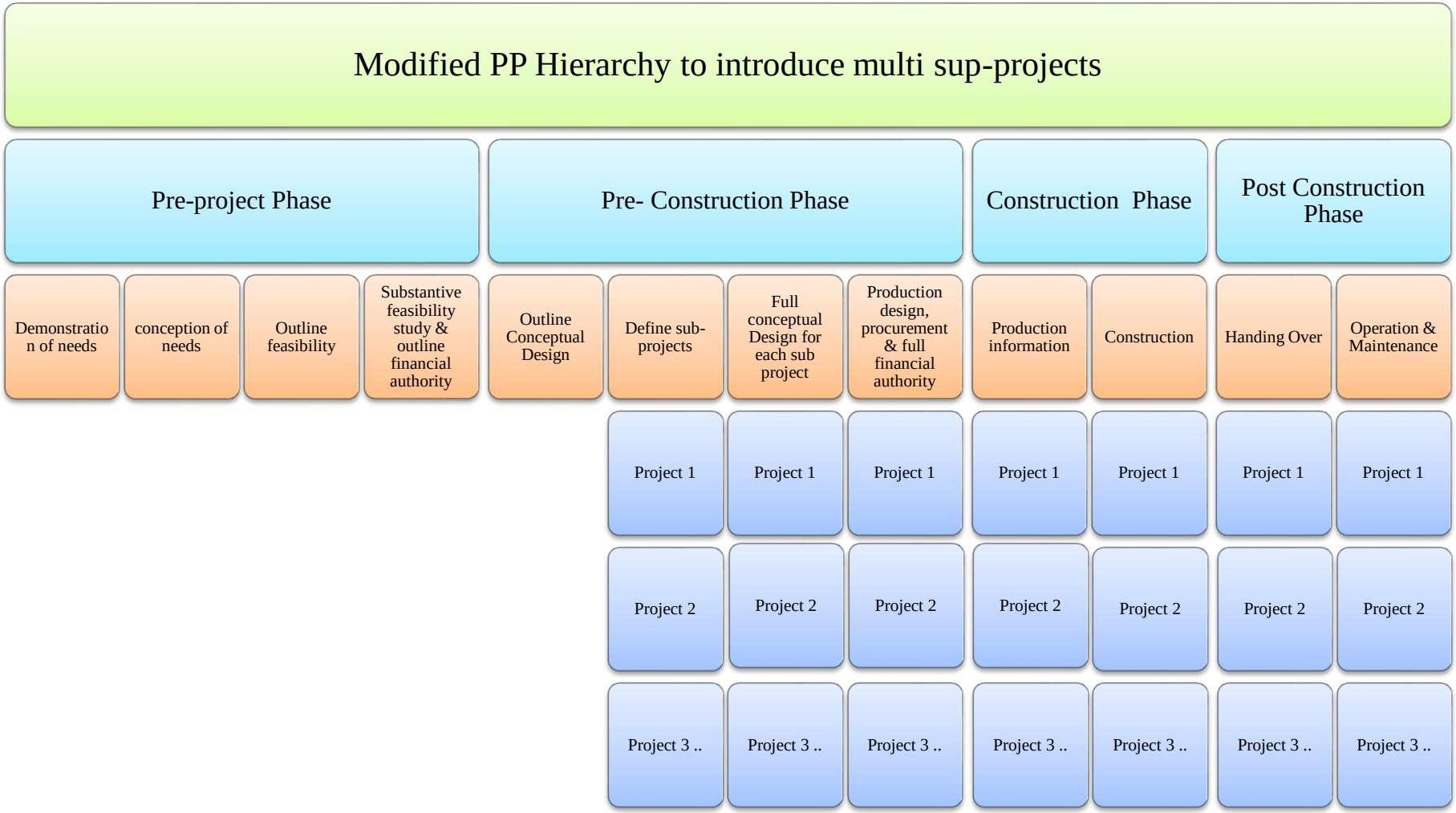


Figure 5.3: Sub-Project Definitions

5.3. The Modified PP model

The following modified PP model is suggested to address the earlier discussed limitations of the PP. (Figure 5.4,5.5,5.6)

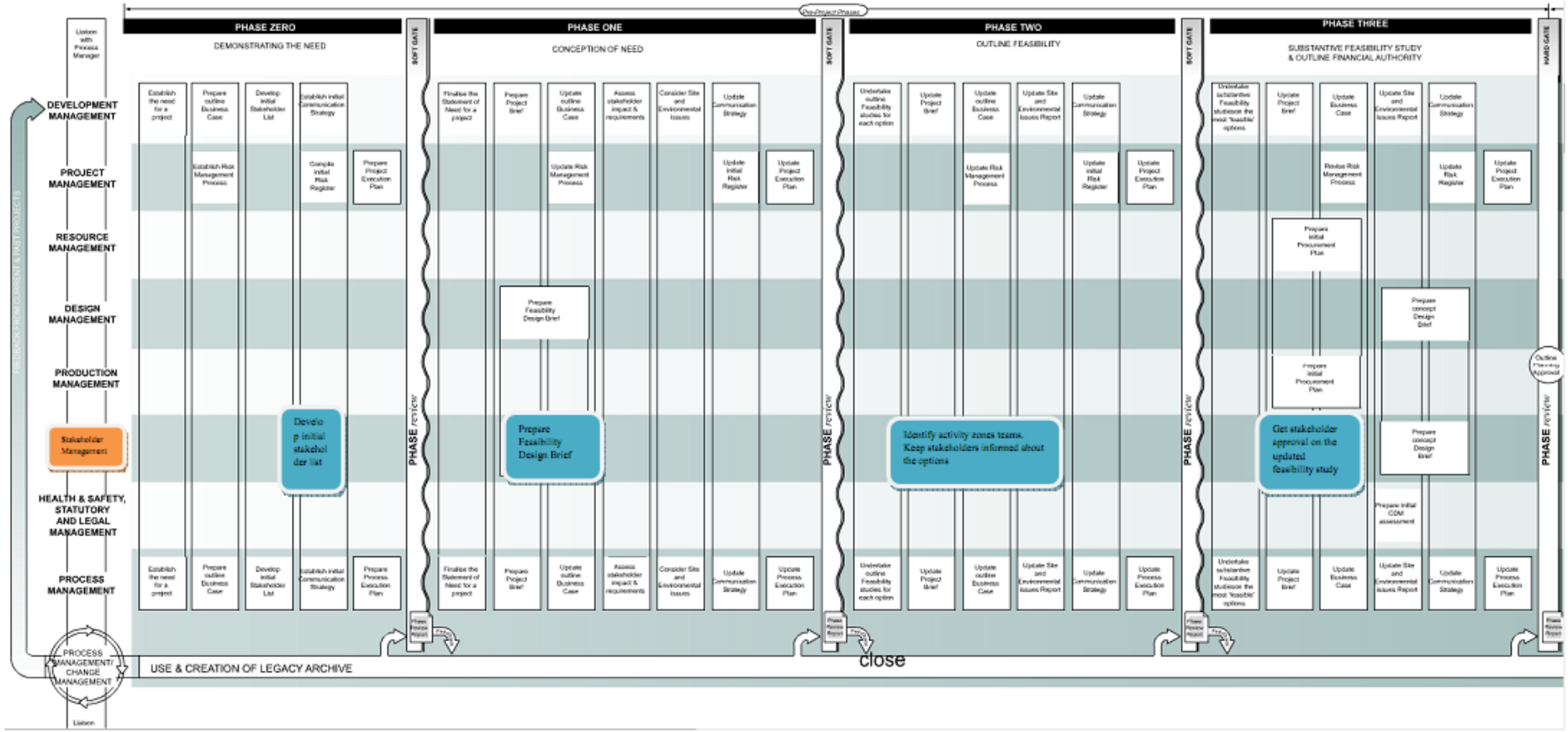


Figure 5.4:Pre-project Activity in the Modified PP Model

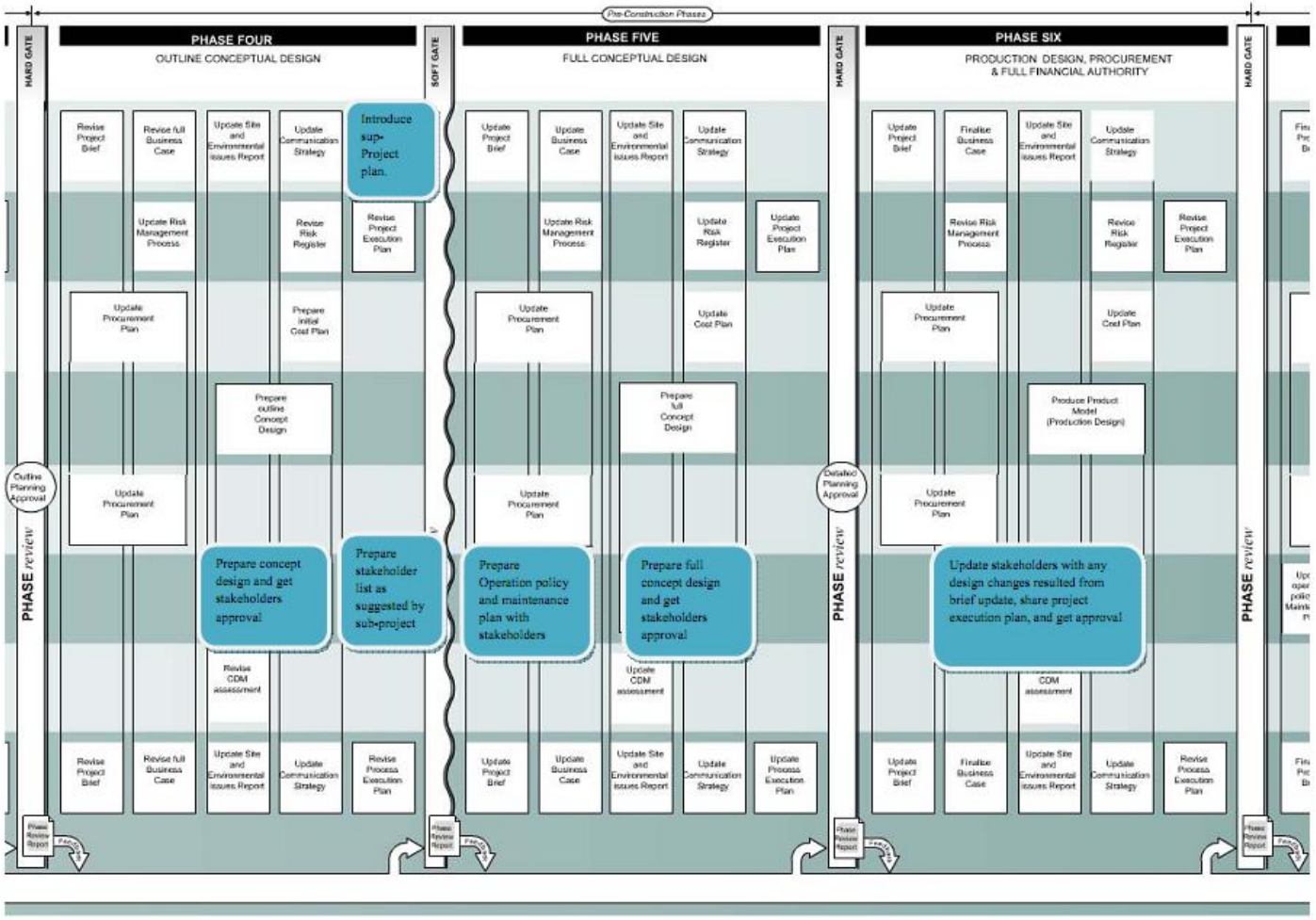


Figure 5.5:Pre Construction Phases in the Modified PP Model

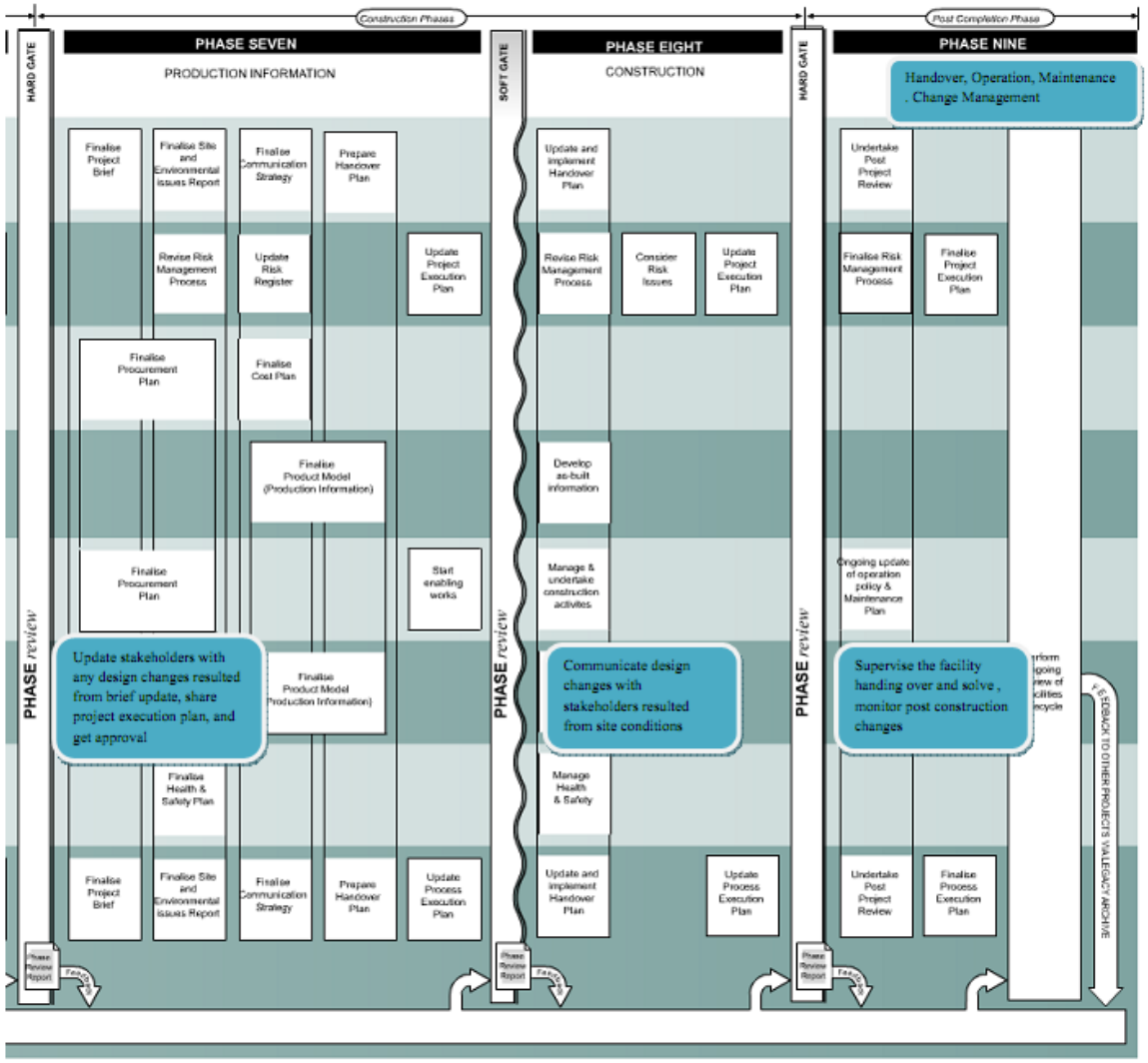


Figure 5.6: Construction and Post Construction Stages in the Modified PP Model

The modified PP model will be discussed in detail in the following with focusing on the role of Stakeholder management activity zone.

Phase 0: Demonstrating the need:

In this phase, the client's business needs are demonstrated and the problems facing the client are defined. It is important to indentify the key stakeholders and their requirements in order to develop the business case which will be in line with the client's overall business objectives.

The facility end-users communicates the problems they are facing to the CA through the Stakeholder management and their needs will be studied and compared to the strategic plan drawn for the Airport Master planning,. Stakeholder Management activity zone will confirm carrying out the necessary activities to produce the initial stakeholder list and needs, and discuss with development management how to implement these requirements.

The goal of this stage is to establish the project needs that satisfy the client's business case and grant approval to proceed to Phase 1.

Phase 1: Conception of need:

The needs statement will become at this stage a structured design brief. All stakeholders' needs are identified and captured allowing the establishment of the design options.

Before this phase the approval to proceed to this phase is obtained. Furthermore, initial approval for funding the project is gained and the study of initial clients needs shall be available along with defined project stakeholders.

Stakeholder management activity zone will contribute to defining the design brief and statement of needs, and produce detailed stakeholder list.

At this stage the available options are identified and initial process execution plans are conducted.

By the end of this stage, the potential solutions for the problems and needs are identified to be discussed in the feasibility study, and financial approval to proceed to Phase 2 is guaranteed.

Phase 2: Outline feasibility:

At this stage the feasibility of the project is developed along with narrowed solutions that best present the client's objectives and business.

Before this phase, the new project stakeholders and participants are introduced and the core teams who will perform the work at the activity zones are appointed.

During this stage feasibility studies for the options are undertaken and discussed with stakeholders through the stakeholders' management activity zone. All necessary planning approvals and the business case are revisited in accordance with the presented options.

Phase 3: Substantive feasibility study and outline financial authority:

In this phase, the decision to finance the right solution for concept design development is carried out along with project outline planning approval.

Before this phase the business case and design brief is redefined based on the outline of the feasibility study results.

During this phase, stakeholders' management team challenges the stakeholders' needs in order to make sure that these needs are studied from all perspectives. The cost and benefit analyses are conducted, and the statutory approvals are obtained.

The concept design plan is introduced at this phase and it is important to highlight that Stakeholder management activity zone plays important role in finalizing the objectives of this phase since the gate to proceed to the phase 4 is 'Hard'. As these outlines given to proceed to concept design stage shall be thoroughly defined and any later change to the result of this stage shall not have significant impact on the criteria or principle defined at this stage, only fine-tuning can be accepted.

Phase 4: Outline conceptual design:

The chosen option is outlined according to the project brief. Options for design approaches are presented for stakeholders' selection and the major design elements are identified.

Before the phase, the systems are defined along with criteria for evaluating these systems such project timescale and resources requirement. The area of interface and interactions between different disciplines shall be identified to enable communications between different parties.

During the phase, the concept design outline is produced, project and systems solutions are refined and basic design schematics are produced such as Models,

Presentations and Elevations. It is important to study the implications of system solutions in relation to the overall project at this stage.

As mentioned earlier, the sub-projects inside the main project are introduced and the adequate teams are allocated to handle each sub-project. At the end of this phase, the sub-projects of the main project shall be identified, and outline concepts shall be introduced for further discussions. By gaining approval to proceed to Phase 5 designers shall try to freeze some components of the design project for example the built-up area, major systems and some MEP requirements. Although the concept design stage is usually have 'soft' gate at the end. However, the segregation of sub-projects might require freezing major building outlines at this stage.

Phase 5: Full conceptual design

This phase presents the chosen solution in more detailed form to include works such as Architecture, MEP and Structure. This phase and the next phases' activities will be carried in parallel to each sub-project (Figure 5.3).

During this phase, the system concept design is developed along with interface studies and resourcing requirements. By the end of this phase the full concept design will be frozen and ready for detailed planning approval.

Stakeholder management is responsible to gain stakeholders sign off on concept design stage in order to proceed to the next stage.

Phase 6: Production design, procurement and full financial authority:

Co-ordination of design information will take place at this phase. The detailed information provided should enable predicting the cost, design, production, and maintenance issues. Financial authority shall ensure the enactment of the developed work at this stage.

Before this phase, criteria for co-coordinating the design between different disciplines shall be agreed. Design Management team will have important role in coordinating the proposed segregation of the different sub-projects while Stakeholder management will ensure that the produced design is meeting the stakeholders goals and objectives.

During the phase, coordinated project model is represented and major deliverables of the project are reviewed. By the end of this phase all major design elements shall be fixed and funding stakeholders' approval shall be gained.

Phase 7: Production information:

The design change shall not be allowed beyond this phase. Planning of the construction based on the detailed design will be conducted.

During this phase, coordinated fabrication design for the final product is produced and production process map is developed for on and off-site activates for each sub-project. Enabling works can start at this phase and Stakeholder management will discuss with the end-users any changes that might arise and get their approval on mock-ups if applicable.

Phase 8: Construction:

All effort done on previous stages shall contribute to have 'trouble-free' construction of the project. However if any problem rises during construction it shall be communicated with other activity zones in order to record and analyze them. This will ensure the learning from mistakes in the future projects.

During this phase, all construction works will be going on. Costs, material and quality of works will be managed and monitored, beside that, handing over plan will be proposed.

It might be useful to coordinate the future needs of the stakeholders through Stakeholder management activity zone, since the life span of complex building is long and new requirement might accrue, hence, some of the modification might be manageable during construction, this will be helped by Change Management team in providing framework to conduct such modification.

Phase 9: Handing over, operation, and maintenance and change management:

As mentioned earlier, handing over the facility is long process and especially when complicated systems are involved. Therefore, this stage will ensure smooth handing over process. As-built designs are documented and handed-over to the facility managers, training and familiarization will take place in order to ensure that the end-users are capable to running the operation and maintenance works.

As mentioned earlier, any changes inside the facility shall be communicated with the design team to ensure they are not affecting the complex coordination network between the systems and to ensure that these changes are not in conflict with the agreed design brief and criteria.

It is important to measure the stakeholder's satisfaction and provide assessment criteria for the success of the project during this phase.

5.4. Adopting Stakeholder Management Strategy

As discussed in the literature it is important to identify and classify the stakeholders involved in the project, moreover, the case study observations do not demonstrate standard practice for dealing with the stakeholders. Hence it is proposed to do this exercise by defining the stakeholders in the airport projects as following:

1- Produce Generic Airport Stakeholder list (Refer Table 2.9).
2- Define Internal and External stakeholders to the design process. (Refer to Figure 5.7)
3- Develop stakeholder power – interest matrix (Refer to Table 5.1 & Table 5.2).
4- Produce design process stakeholder list (Refer to Table 5.2).
5- Identify stakeholder requirement and needs from the design process (Refer to Table 5.2).
6- Define tasks and deliverables of the Design Management and Stakeholders (5.3).

The generic list of stakeholders in any complex project is essential in order to know who the project stakeholders are and what their objectives from the project are. This will help designers to develop more clarity about the function of the conducted design, and how to orient the design based on the thought of the stakeholders. The Generic Airport Stakeholder and their objectives showed in Table 2.9 by Schaar and Sherry (2010) is appreciated by the interviewees and they highlighted that it is very useful tool when establishing Stakeholder Management manual.

Through the conducted interviews and reviewing the case study documents, it is found that stakeholders of the design process in the case study can be classified as

shown in Figure 5.7. The internal stakeholders are the departments who are producing the design and interacting with the external stakeholders to make sure that the design is meeting their requirements according to their power and interests. In this case study, CA is representing the neutral organization which tries to find balance between all involved parties requirements.

The power of the involved parties varies according to their needs. The Local airline carrier in the case study (and in most of the airport projects) is the most important stakeholder since the airport is being built to fulfill the business expansion needs of that entity. Also, the airport operation needs are important in order to meet the business requirement of these stakeholders which should be given adequate attention in the design process. Commercial organizations such Duty free are also very important since they provide significant revenue which should not be overshadowed by the revenue produced by the local airline carrier.

The government funding authority has a high power since it provides the capital for project execution. However, the design process is not their main concern since it meets the allocated budget. Governmental federations such as the police, immigration and customs are in a similar situation.

Business organizations such as food outlets operators and foreign air carriers have an interest in running their business at the airport. Although they usually do not have power to influence the design process, it is important to provide them a facility that attracts their business and provide them with adequate facilities.

Passengers, communities and NGOs don’t have significant impact on the design process. However it is important to keep an eye on these stakeholders since they are providing the data index to the design process (such as passenger requirement from the airport facilities like entertainment and services).

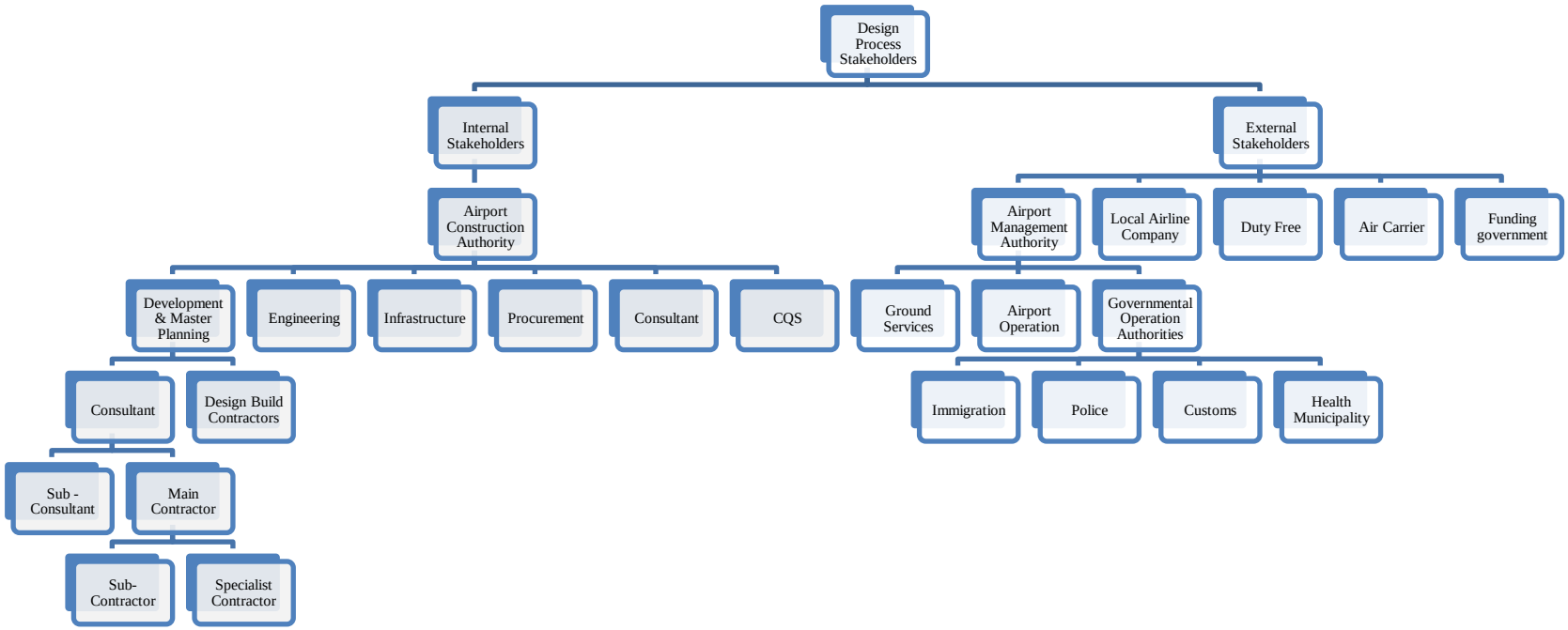


Figure 5.7: Internal- External Stakeholders to the Design Process

Power	High	- Government as funding authority. - Government operation Authorities -	-Local Air Carrier -Airport Management and Operation - Commercial organization
	Low	Passengers Communities NGOs	 -Business Organization -Foreign Air Carrier
		Low	High
	Interest		

Table 5.1: Stakeholders Power – Interest Matrix

Stakeholder Group	What is the need of this group from design process?	Power (1 is low, 4 is high) of this group in the design process
Passengers	Easy movement and smooth operational process.	1
Local Air Carrier	Fulfill the operational requirement in order to serve the desired level of service	4
Foreign Air Carrier (All Other Airline AOL)	Standard operational facility	3
Airport Management and Operation	Fulfill the operational requirement in order to serve the desired level of service	4
Funding Government	Facility that needs the government vision in most cost efficient way.	3
Communities affected by airport operation and	Noise, emissions issues, aesthetic view of the facility, easy access.. etc	1

NGOS (Environmental Bodies)	Meeting environmental and sustainability goals	1
Business and Commercial organizations	Ideas and facilities that meet the investment and return requirement	3
Government authorities (police, customs , immigration, medical …)	Meeting operational and security requirements.	2

Table 5.2: Stakeholder Power Level and Needs

The case study is limited to interviews from Airport Suppliers, Business and commercial organizations, Airport management and operation, Local Air Carrier, as they are directly involved with the design process. Consequently, the remaining categories presented by Schaar and Sherry (2010) are not considered as they do not have significant impact on the design process or they are not existing in the Case Study.

Based on the case study stakeholders' management observation discussion and literature review, a map of design management and stakeholders' task and deliverables in each design stage is developed. This map is achieved through collaborative work between consultant, CA and stakeholders. This map addresses the issue of pre project activities, design brief and design criteria. Moreover it presents a control point through forms and reports that can control the project documentation. Table 5.3 shows a matrix of tasks and deliverables of CA and Stakeholders.

Pre-Project Activities:

Stage	Design Management	DM Deliverables	Stakeholder Tasks	Stakeholder Deliverables
1 Identification of Need	Depending on operational or planning requirements arising for DM or stakeholder.	Strategic Brief including 'opportunity identification plan' and early cost	Identification of business requirement through strategic planning or operational feedback	Project initiation letter to DM Form 1
2 Feasibility Stage	• Pre - feasibility Assessment • Collection of data. • Any other necessary pre-conditions • Requirement management • Macro analysis	• Project Charter* • Solution Brief / Project commitment which clearly articulates business scope, cost, business quality and time targets for a solution	• Goals and objectives • Initial commercial input • Business case formulation	Initial Data Report Form 2
	Developing Solution / Project Brief • Feasibility analysis Defining: • Options (strategic choices, strategies, policies…) • Practical solutions (constraints) • Defining direction • What to be constructed? • What is the budget? • Codes, regulations, guidelines and standards governing the solution	• Data Collection Report Report 1 • Feasibility study Report 3 • Project Brief Approval Form 3	• Gathering and consolidation of initial stakeholder input • Production of traffic forecasts (annual/seasonal/design day schedules)	• Data Collection Report (Stakeholders)* Report 2 • Business Case including: ➢ Level of service definition ➢ Operational considerations and regulations input
3 Project Design Brief Stage	• Development of the Design Brief. • Sketch ideas, moods, key finishes and color palette. • Preparation of budgetary estimate and preliminary cash flow forecast. • System consideration (integration) • System optimization • Generating concepts • Evaluating Concepts • Design criteria for	• Project Design Brief Report including design critera Report 4 • Budgetary Cost Report. Report 5	• First level operational simulation • Initial production of facility requirements • Stakeholder review and feedback to the Project Design Brief Report • Review and analysis of Budgetary Cost report	• Consolidated stakeholder feedback on Project Design Brief Report Form 4 • Stakeholder Financial Assessment of Budgetary Cost report. Form 5

	project elements			

Design Phase

Stage	DM tasks	DM Deliverables	Stakeholder Tasks	Stakeholder Deliverables
4 **Concept Design Stage**	• Coordination with Stakeholders for special requirements. • Coordination with Specialist Consultants as necessary. • Preparation of space planning and basic layouts. • Concept design drawings • Colored perspectives to explain the schematic design • Material boards to illustrate material selection. • Walkthrough if necessary. • Tabulation of built up areas, fire safety issues and indicative outline of finishes, materials and landscaping • Architectural narrative as well as engineering conceptual write-ups	• Concept Design Report CDR Report 6 defining: ➢ What are the determining parameters? ➢ Initial value engineering Report 9 ➢ Conceptual design ➢ Concept Design Cost Estimate. ➢ Design Brief Approval Form 6	• Stakeholder Analysis and Feedback on: Functional adjacencies and flows • Physical planning inc. preliminary architecture / engineering • Phasing and constructability • Operational SME input • Operational resource requirements • Second level operational simulation (concept validation)	• Concept Design Report (Stakeholders)* Report 7 • Stakeholder approval of CDR Form 6 • Detailed Stakeholder Financial Assessment Report 8

	for all project systems. • Design Brief Development / Approval Engineering • Preparation of Concept Design Cost Estimate.			
5 Preliminary Design Stage (if Applicable)	• Coordination with Specialist Consultants as necessary. • Preparation of advanced space planning and basic layouts. • Preliminary design drawings • Material boards to illustrate material selection. • Tabulation of built up areas, fire safety issues and indicative outline of finishes, materials and landscaping • Architectural narrative as well as engineering preliminary write-ups for all project systems. • Preparation of Preliminary Design Cost Estimate.	• Preliminary Design Report Report 10 • Preliminary Design Cost Estimate. Note 1	• Detailed stakeholder input • Detailed operational SMEs analysis and input • Third level simulation and operational validation/approval	Stakeholder approval of PDR Form 7
6 Draft Final Design Stage	• Detailed designing for the project. • Preparation of Draft Final Design drawings for all trades including but not limited to	• Draft Final Design Drawings and Specifications Report 11 • including: ➢ Concept Design Enhancement	• Detailed stakeholder input • Detailed operational SMEs analysis and input	Stakeholder approval of Draft Final Design Drawings and

	Architecture, Interior Design, Structure, MEP / SAS, landscaping. Preparation of Draft Final Design Specifications. Conducting a value engineering Session as necessary. • Preparation of Draft Bill of Quantities. • Preparation of Draft Tender and Contract Conditions.	➢ Platform, modularity, overall design. ➢ VE report and recommendations. ➢ Draft Bill of Quantities. ➢ Draft Tender and Contract Conditions.		Specifications Form 8

Tender and Award Phase

Stage	DM tasks	EP Deliverables	Stakeholder Tasks	Stakeholder Deliverables
7 **Final Design and Tender Stage**	Final Design and Tender: • Drawings and Specifications. • Consultation with clients, end users. • Approve design • Design review • Preparation of Tender Bill of Quantities. • Preparation of Tender and Contract Conditions.	• Final Design Drawings and Specifications Report 12 • Value engineering Report 13 • Constructability study Report 14 • Tender Bill of Quantities and Tender and Contract Conditions. Report 15	• Linking detailed stakeholder input and detailed operational SMEs analysis and input to final design	• Stakeholder approval of Final Design Drawings and Specifications / Cost Estimate / Draft Schedule Form 9
8 **Tendering Stage Award of Project**	• Preparation of technical Contract documents. • Float tender • Issuance of query responses, clarifications, and	• Technical Tender Evaluation Report (TER) and Post Tender Clarifications (PTC) Matrices. Report 16	• Technical aspect to be discussed if any specific issues arise. MoM 1	Confirmation of Project Content/Cost /Schedule Form 10

	addenda. • Opening of Tender and evaluation. • Negotiations with Tenderers. • Evaluate renderers and award tender • Develop milestones with potential contractor • Develop contract			

Table 5.3: Tasks and Deliverables of Design Management Authority and Stakeholders

It is important to highlight that this table is limited to the design stages as per the scope of the research. However, this roster shall be expanded to cover the other stages of the project in order to achieve a proper linkage with proposed model later in the research.

The developed design management-stakeholder tasks and deliverables matrix (Table 5.3) will be the guideline for task and deliverables of CA and Airport stakeholders through the project design phases. Stakeholder management will be managing the implementation of this list.

5.5. Model Application

The research faces limitation in providing empirical validation for such model. This is due to the fact that changing the current practice has several implications such as cultural, technical and practical. Moreover, it needs long time to apply this model to the CA and test the results since the design life cycle is extended up to years in a project like Aircraft Concourse.

Therefore it is suggested to provide example of applying this model virtually on Airport terminal project in order to suggest what activities to be carried out during each phase.

5.5.1. Identifying the members of the activity zones

Development Management: (Dev)

Dev is responsible for creating and maintaining the airport projects portfolio focused on business in order to achieve the satisfaction of both relevant organization and stakeholders' objectives and constraints throughout the life of the airport project and other projects handled by the organization.

Proposed members in this activity zone are:

1- Head of Architecture Department
2- Head of Procurement Department
3- Specialist advisor in Airport construction.

Project Management: (Proj)

PM is responsible along with process management for effective and efficient implementation of the project as per the measures defined in the design. This construction team is responsible for executing and delivering the facility as planned in the business case.

1- Senior Construction Manager
2- Planning Officer

Resource Management (Res):

Res look after the planning, coordination, procurement and monitoring of all financial, human and material resource. This team defines material and human resource requirement in addition to procure these requirements as per project demand.

The proposed members are:

1- Procurement manager
2- Project Management
3- Human Resource

Design Management (Des):

Des handles the design process that converts the business case and project brief into properly defined product, it guides and ingrates all design input from other activity zones. The DM team will always be from the Consultant team. In the Pre-project stage this team usually is the master planning consultant of the airport who

has done the existing airport master planning. This consultant involvement might be suspended after pre-project stage in order to have competition in providing the project design.

Suggested members:

1- Chief Architect
2- Electrical Manager
3- Mechanical Manager
4- SAS Manager
5- IT Manager

These managers will be managing the design process with the assistance of lower category teams in the same specialization.

Production Management (Prod)

Production management ensures the best possible solution for the build-ability of the design, construction, logistics and organization for the product delivery. This task is handled by the main contractor who is reporting to Construction manager as a member in the Construction Authority.

Suggested members:

1- Construction Manager.
2- Senior Architect (or MEP engineers where applicable)

Health and safety, statutory and legal management (H & S)

H & S identify, consider and manage regulatory and environmental dimension of the project. This team will consider the safety issues raises at site beside the environmental consideration during design and implementation of the airport project.

Suggested members:

1- Health and Safety Manager
2- Architect and Engineers

Process management (Proc)

Proc develop and operates the PP along with monitoring and planning every phase. Proc is responsible for executing the process plan, in close collaboration

with project management, in addition to review the phase plans and reports along with determining and examining the inputs and outputs of the process and monitor the deliverables of each phase.

Suggested members

1- Planning Manager
2- Construction manager
3- Document Control officer

Change Management (CM)

CM is responsible for effectively communicating project changes raises at any stage to all relevant activity zones. CM receives and categorises change information, distributes these changes to the respective disciplines, review and modify and update project archive. This team responsibility can be undertaken by Process Management team. Therefore, the team members are the same.

Stakeholder Management (SM)

The scope of this team has been explained earlier in this research. The suggested team members are:

1- Architecture manager
2- Construction Manager
3- Operational Readiness and Airport Transfer (ORAT) Manager
4- Consultant representative

Architect manager and Construction Manager are required to challenge the end-users requirement from their previous experience, validate these requirement and carryout empirical studies where applicable. The architect might be replaced with MEP engineer, system, or IT engineer where validating the system requirement is required. ORAT manager is required in the handing over stage, and they are not necessarily being involved in the initial stages of the project.

It is important to highlight that the above team members are only proposed members and they can be changed according each project conditions or phase requirement.

5.5.2. Example for applying the model in preparing initial statement of needs

This stage is part of Phase 0 which is the demonstration of needs phase. The first task in this stage according to Salford University (2002) is to develop Initial Statement of Needs as Level 1 of the deliverable as shown in Figure 5.8. Level 3 and dependency stakeholders are shown in Figure 5.9.

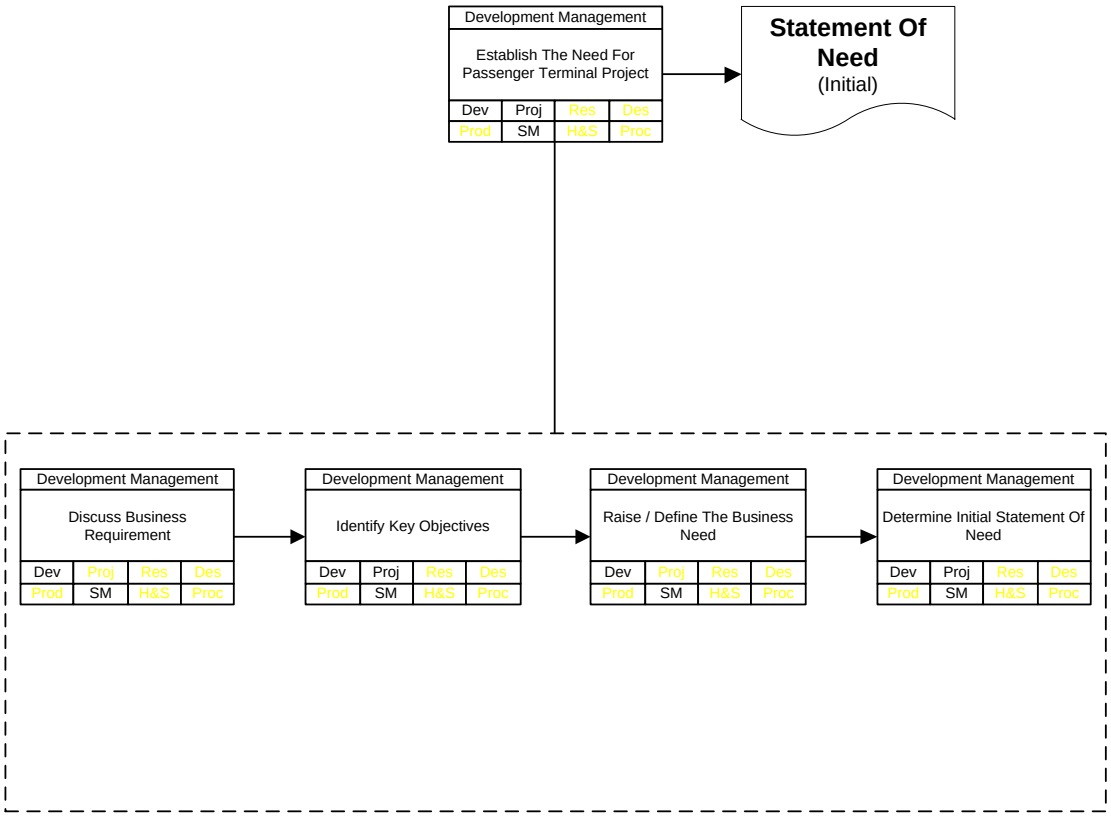


Figure 5.8: Level 1 and Level 2 in identifying initial statement of needs

In order to define the Level 4 and 5 of tasks involved, a table sheet has been developed in order to identify the lower level of the tasks, time required to complete the tasks, stakeholders' dependency, and result of the conducted task. The example shown in Table 5.4 shows the Level 3, Level 4 and 5 of "Discussing Business Requirement" presented at Level 2.

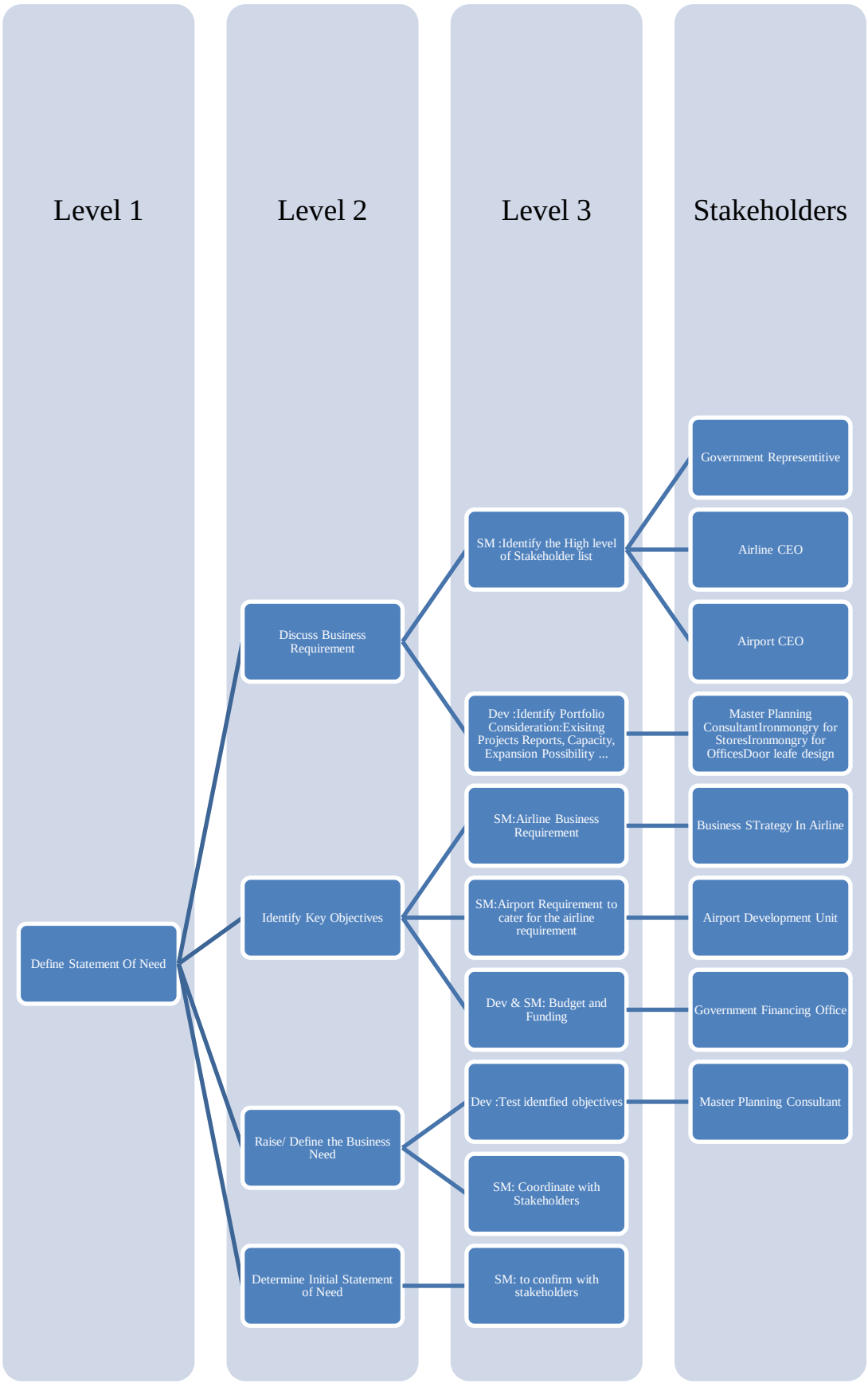


Figure 5.9: Level 3 of Details and Stakeholders List Matrix

It is proposed that this schedule will be linked to software that records these tasks along with the stakeholders' dependency. Moreover, the input of each task will be saved in the project history and the process manager will add the results that come from that task to the initial report of the design criteria which will form a contract between different stakeholders. These design criteria will be developed further through the progress in each phase of the project and it will end up at the end of the project by developing a manual for the design of this airport.

By adding the time to this sheet a planning schedule will be formed and the high level task manager will have an idea about the completion date of the high level task.

It is required to conduct further investigation to understand the work involved in this phase in order to produce more accurate and detailed list of tasks along with more specific personnel representing the stakeholder involved in making or coordinating the decision with Stakeholder management zone.

The integration of this list with the software will result in powerful tool for design manager. This tool will help in tracking the project tasks and monitor what is required to complete the high level of the design task. Such tool will produce a progress report easily with the aid of the software. Furthermore, it can be linked directly with the stakeholder who is supposed to respond to the design task in order to accelerate the response to complete the design criteria. Moreover, this list can allow the stakeholder at the end of the task to raise further subtask if there is a feeling that design decision cannot be taken at the level of the stakeholder so he/she can develop further questions to be answered.

This tool also can be helpful when site observations are conducted. In that particular case, the high level will define the stakeholders supposed to conduct the observation and the result of their observation will be treated as a guideline or a role for design (Refer to the example of toilet sizing presented in case study analysis).

As a conclusion, the example given has answered the points raised at the case study analysis such as information management, organizational issues and linking stakeholder management to the design process. The next step will be to validate such a model as a generic model that describes the design process and airport management.

Appendix (V) shows the proposed Level 2 tasks in Phase 0 and Phase 1.

Level 3	Task owner	Time	Level 4	Time	Stakeholder dependency	Result	Level 5	Time	Stakeholder dependency	Result
Identify the high level of stakeholder list	Stakeholder Management	7 days	Define government representative	7 days	Government	Assign VP Funding				
			Define Airline representative	7 days	CEO Airline	VP Business strategy				
			Define Airport organization representative	7 days	CEO Airport	VP development				
Identify portfolio consideration	Development management	7 days	Provide fact sheet about existing facility	7 days	Master planning consultant	Report				
			Study the ability to expand the existing facility	3 days	Development Management Master planning consultant	Level 5	Study apron plot	3days	Infrastructure Department	Report
							Study the capacity of child water utility	3days	Mechanical department	Report
							Capacity of transformer	3days	Electrical department	Report
							Network expandability	3days	IT	Report
							Baggage handling system	3days	SAS	Report
			Study existing operational constrains	5 days	Stakeholder Management	Level 5	Initial report of end-user complains	5days	Service provider	Report
								3days	Airport operation	Report

Table 5.4: Level 4 and Level 5 Tasks Sheet

5.6. Model Validation

As explained earlier in the research methodology chapter, model validation is done based on the results of a focused group consisting of key managers and employees in the Construction Authority.

The result of presenting the modified model and the application example showed that all participants agreed that the model is generic and describing the complete design process of the Airport design from wider point of view than the existing practice. The described activity zones are matching the discussions conducted between different disciplines in each phase to take decisions about the project however in more systematic manner. The highlighted early involvement of construction team in the model is appreciated by all participants and they agreed that it is useful to identify the input required from construction team on the task level of design process. However, it was pointed that the involvement of specialist supplier and contractors is not always feasible and it has limitations in terms of it might be understood as an advantage in awarding the job later and will prevent other contractors to bid for the project. The introduced concept of fixing design before dividing the package is valued and it started being implemented in recent projects handled by the CA.

The introduced stakeholders' management strategy and the matrix of design management – stakeholders' tasks and deliverables gained the participants acceptance and it is agreed that it represents a clear framework for the relation between stakeholders and design management. The idea of finding the balance between the different stakeholders of the project through the stakeholders' management techniques gained acceptance, and it was suggested to introduce the concept of renting the required space for the stakeholder, where in that case, every department manager at the airport knows that the allocated space for them is not free and they need to allocate a yearly rental budget to that space.

Many participants agreed that the idea of decomposing the design process into documented individual task is a useful way to record the process of the design and save it in the project history or update it in the design criteria which will contribute to solving the issues related to information management and design standard. Other participants reserved that listing the design task might be long process and time consuming. Hence imperial evidence if required for applying such model especially when having massive project size such the case study.

Some of the participants stated that this model is valid since that the CA is implementing the stakeholder management and design task management using traditional tools without the aid of software that records the design tasks and stakeholders inputs. Therefore, implementing such a model will facilitate the work of managing the design process and stakeholders requirements.

One of the implementation concern observed is related to the culture of the employees in the CA. Most of these employees are highly experienced and used to the traditional way in managing such design. Hence, there is always resistance to implement new techniques.

Other implementation issue is raised against the organizational matrix of the different disciplines. The suggested teams seem to be adding additional complexity to the project organization rather than simplifying this matrix. Hence such implementation requires more studies on the organizational levels of the CA in order to allow such matrix implementation. However, it is suggested to implement the model by keeping the existing CA organization and redefining the activity zones to suit the CA work procedures.

It is agreed that the model will add additional impact on the Document control department which will be promoted to take the role of process management. As a result, it needs a further study to identify procedures, forms, checklists, and how this will be monitored and linked to the IT software. Moreover, it requires to recruits experienced staff in managing and monitoring construction processes.

Some of the participants raised concerns regarding managing the complexity of the coordination network between different disciplines and stakeholders when tasks and stakeholder list become more complicated, therefore it is suggested to have a clear framework that describes the IT solution provided to manage this network and how can this IT software being extended to manage the different activity zones including change management.

The result of this focused group revealed that the adopted model for design process and stakeholder management is valid and can represent the design of Airport construction as a complex project. Further development for this model is required such as extending the scope of the IT software, studying the organizational implication of implementing the model, and defining the structure of the process documentation framework. In addition, it is also recommended to

imitate studies in applying such a model in real projects with certain extend of complexity.

The interviewees concluded that this model demonstrates a clear and detailed description for the design process of airport design and it can be used as a frame work for managing the design of such complicated projects. The introduced stakeholder management along with the proposed stakeholder management strategy is important in making sure that the project is meeting the expectation of all involved parties, and insuring the project meeting the planned objectives of the project.

Based on the above, the Aim of having model for Design Process and Stakeholder Management in Airport Construction is achieved in the proposed case study. However the following limitations shall be considered:

The proposed modified model is based on the observation of the case study airport which has certain regional and organizational aspects that might vary from one airport to another. Therefore, the proposed model might not be applicable on other case studies. Therefore, generalizing the findings requires further study and assessments of the practices in other airports. The same statement is applicable in complex construction projects which will have other complexity factors that might require to be addressed in a different way.

The stakeholders of the airport organization might be different between countries and airports as explained in the literature review therefore, stakeholder network complexity might have different dimension in other airports case study, based on that, generalizing the model to cover other airport design and stakeholder management requires further investigation.

Validating the applicability of the model when sub-projects introduced has not been tested. The results of the number of tasks dependency and design task levels might increase and affect the method of controlling the data.

The developed model does not define the sublevel processes in details. This task requires further study and analysis for each phase in order to get the ability to introduce such framework.

Chapter 6: Conclusion

This research examines the design management process in construction focusing on Airport-related projects and their inherent challenges related to project complexity, multi-disciplinary approach, and stakeholder management. While addressing these challenges, an assessment of the design process models in manufacturing was conducted and it was concluded that these models are more advanced and detailed than the traditional building construction design models such as the RIBA Plan of Work.

Modern construction design management models such as the Process Protocol and the Analytical Design Planning Technique have been examined and found to provide a holistic project view. Furthermore, they are backed by a consistent design process management framework that aids the different levels of coordination between disciplines involved in modern construction projects.

It is widely understood that modern construction projects face complexity at different levels such as the organisational, operational, technological, planning, and management layers. However, Airport construction projects have additional complexity factors such as the long stakeholders list and the considerable number of building components and systems.

The Stakeholder Management concept is examined and it is concluded that design managers shall develop the skill and understanding required in managing stakeholders, a process fraught with unpredictable actions and conflicts of interest between stakeholders. The use of tools that facilitate Stakeholder Management, such as the power-interest matrix, is highly recommended and has obvious benefits.

During this process, Airport stakeholders have been closely examined; one soon realizes that the stakeholders form a complicated network of business interests and specific operational goals and needs, with far-reaching consequences on the design of the Airport's facilities, and subsequently, an extensive influence on the design process.

Analysis of a case study from Airport construction project has been conducted and it is revealed that there is a need to have a generic design model that represents the

different levels of interactions during conducting the design of airport project such as information management, managing different levels of building component and stakeholder management. Consequently, the applicability of modern construction design models in representing the Airport construction model has been examined and it is revealed that Process Protocol model is a suitable model for such project. However, it is explained that factors such as Stakeholder management and handling the project size shall be reflected in PP model. Therefore, modified model of PP has been proposed.

The modified PP model addresses the issue of stakeholder management through presenting the Stakeholder management activity zone which deals in coordinating the requirement of different stakeholders in the project from one side, and identifying the targeted stake holders of the design task from the other side. The modified PP model also addresses the decomposition of top levels of the project into sub-projects that can be further decomposed to different levels according to the sub-project complexity in order to reach the individual design task that helps coordinating different disciplines and stakeholders.

A strategy for managing Airport stakeholders was presented and it gave an idea about classifying the airport stakeholders with considering their, objectives from the design process, power and interest. In addition, a matrix defining the deliverables of design managers and stakeholders is proposed to identify clearly the role of each entity in the design process.

An example of applying the model showed that the model provides a useful tool for aiding design managers in managing the airport project design complexity and stakeholders. The results of validating the modified model showed that such model is valid in representing the design process and stakeholder management in airport construction projects with taking in consideration the limitation that need further study such as generalizing the model and the findings.

Recommendation for future work

- The proposed model as explained earlier is still in concept stage hence, further validation, investigation and refinement is required to proof the model value in design and stakeholder management in complex construction projects. This can be tested through applying the model to the

complete project life cycle and monitor the results of shifting form stage to another where the design gets more complicated.

- Further study is required to be done to examine the matrix organization resulted from the activity zone cross function, especially when multi projects are introduced, besides defining each activity zone scope of work and the tasks to be performed.
- Testing the validity of dividing the project into sub-projects in pre-construction stage is required in order to define how that will affect the coordination levels and stakeholder dependency tasks.
- The explained design management variables in airport construction is proposed for further research and investigation as these variables have impact on the model structure depending on each case study.
- The concept of linking Design Management and Portfolio Management is important in complex projects in general and airports in particular, especially that such projects are usually part of organizations that have several strategic projects. Therefore this is an important area for future studies.
- To effectively implement the proposed model, there is a need for translating the theoretical findings of the model into empirical study. This could be achieved by preparing framework for defining the sublevels and propose a standard process for performing such work.
- Managing the changes in the facility after handing over is very important in airports and complex projects, these tasks sometimes are not given to specialist designers hence they might impose defects on the building when applied without proper study. Based on that linking design change and facility management in complex projects is an area for future researches.
- It is important to promote the stakeholders consciousness about the facility, one solution was given about renting the space to each entity in the building so they can feel that their requirements have certain cost hence, further research is required about the effect of optimizing the operation on the building design in airports.

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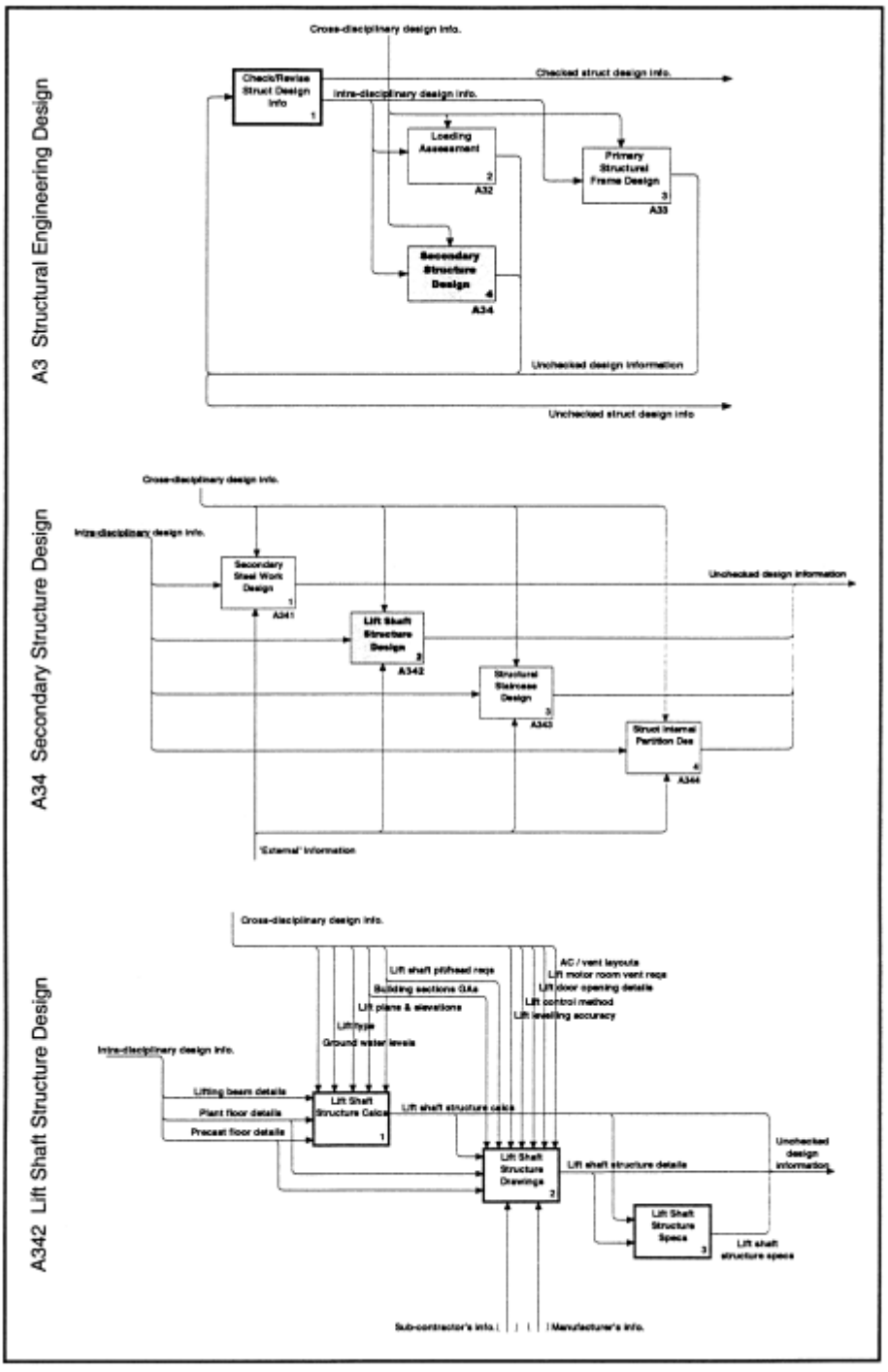
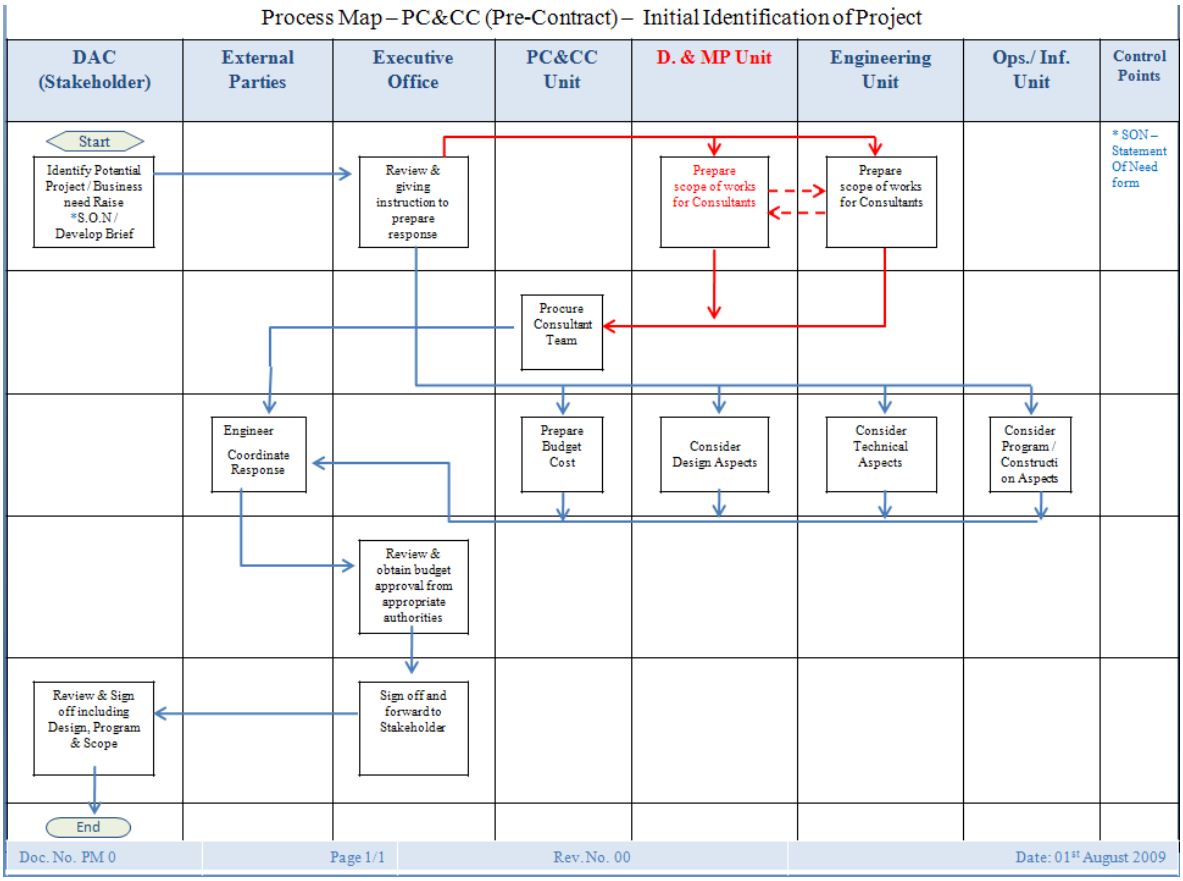
Appendix

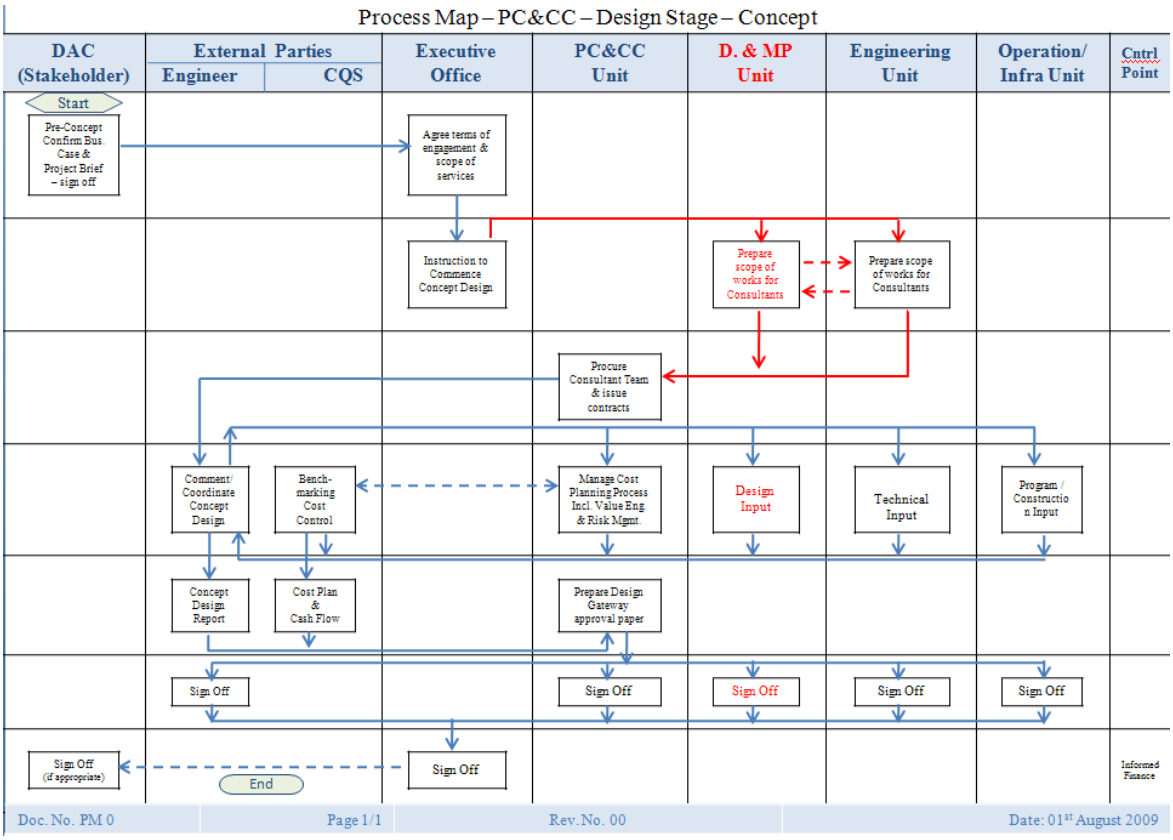
Appendix (I): Design process diagram

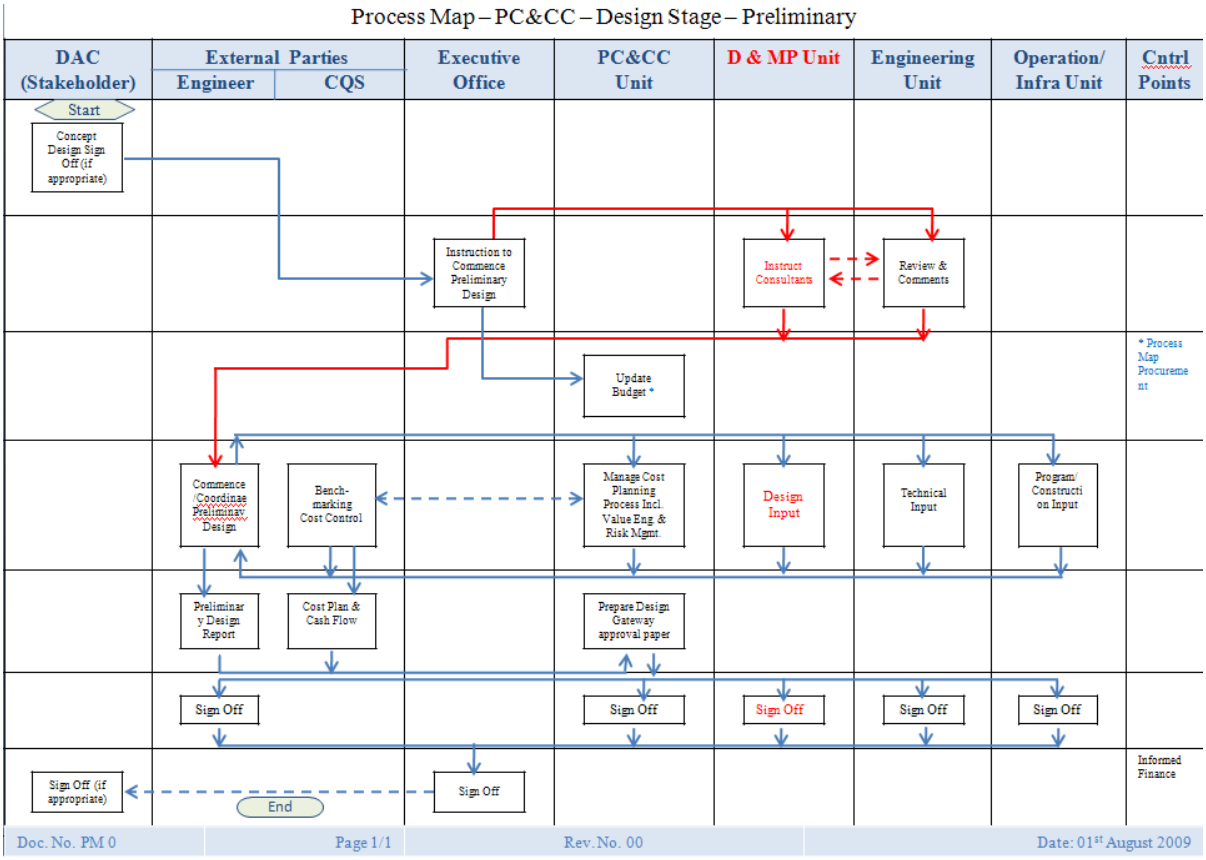


Example of design process diagrams by Austin et al (1999)

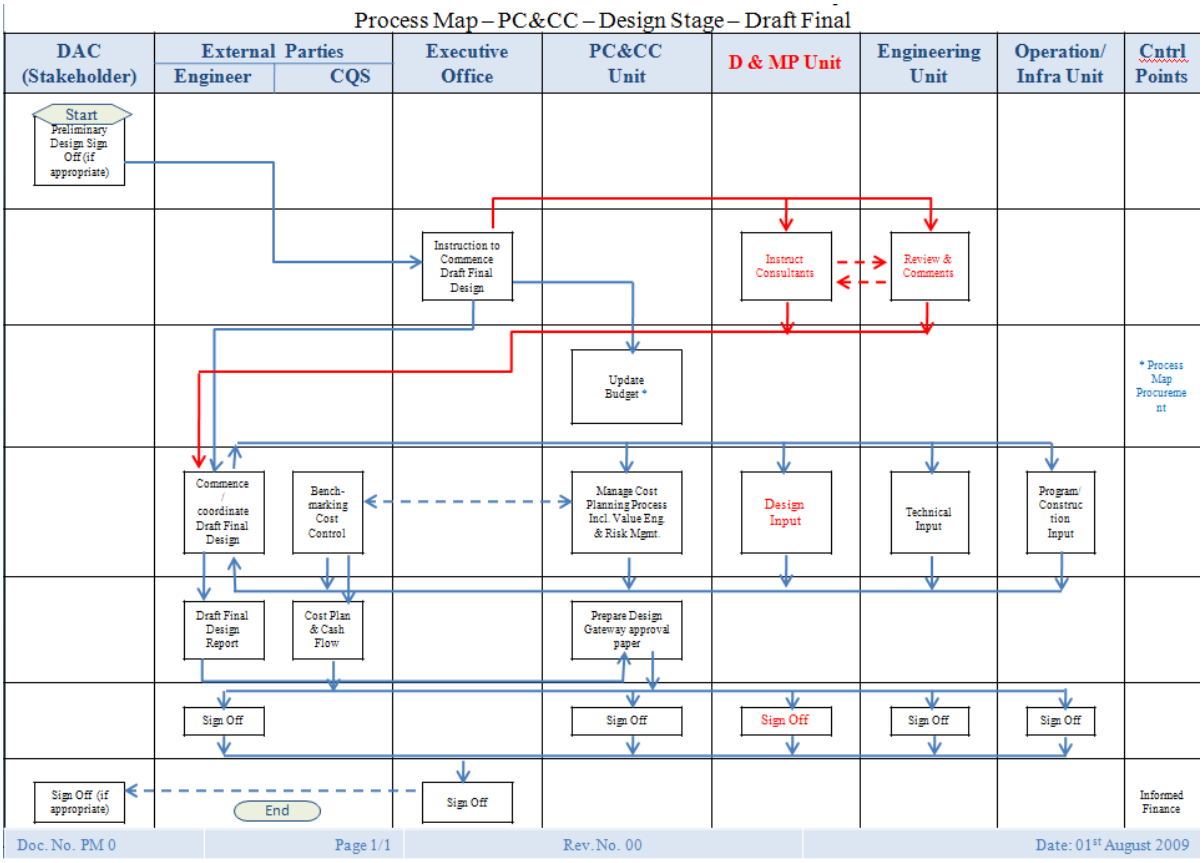
Appendix (II): Construction Authority Process Maps



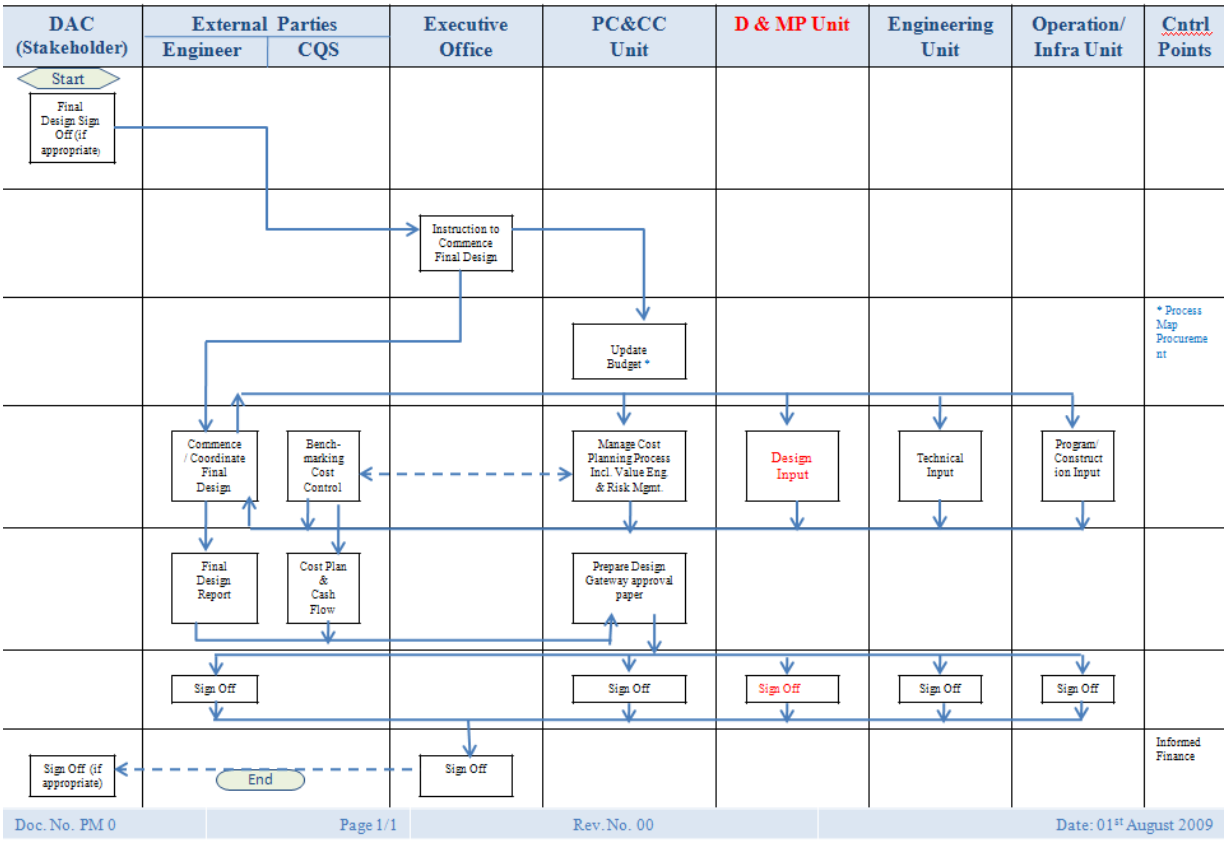

Process Map – PC&CC – Design Stage – Concept
DAC (Stakeholder)
External Parties
Engineer
CQS
Executive Office
PC&CC Unit
D. & MP Unit
Engineering Unit
Operation/ Infra Unit
Cntrl Point
Start
Pre-Concept Confirm Bus. Case & Project Brief – sign off
Agree terms of engagement & scope of services
Instruction to Commence Concept Design
Prepare scope of works for Consultants
Prepare scope of works for Consultants
Procure Consultant Team & issue contracts
Comment/ Coordinate Concept Design
Bench-marking Cost Control
Manage Cost Planning Process Incl. Value Eng. & Risk Mgmt.
Design Input
Technical Input
Program / Constructio n Input
Concept Design Report
Cost Plan & Cash Flow
Prepare Design Gateway approval paper
Sign Off
Sign Off
Sign Off
Sign Off
Sign Off
Sign Off (if appropriate)
End
Sign Off
Informed Finance
Doc. No. PM 0
Page 1/1
Rev. No. 00
Date: 01st August 2009

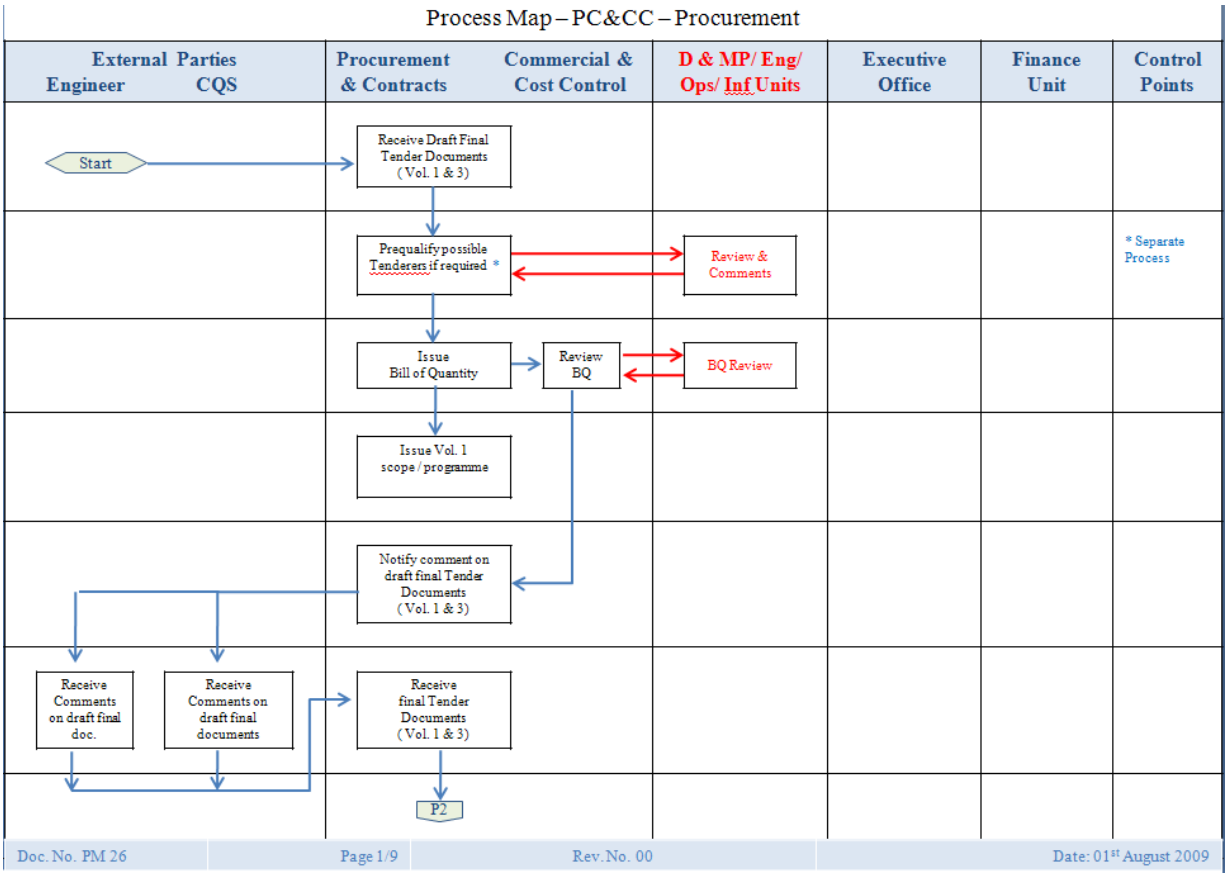

Process Map – PC&CC – Design Stage – Preliminary
DAC (Stakeholder)
External Parties
Engineer
CQS
Executive Office
PC&CC Unit
D & MP Unit
Engineering Unit
Operation/ Infra Unit
Cntrl Points
Start
Concept Design Sign Off (if appropriate)
Instruction to Commence Preliminary Design
Instruct Consultants
Review & Comments
Update Budget *
* Process Map Procureme nt
Commence /Coordinae Preliminary Design
Bench-marking Cost Control
Manage Cost Planning Process Incl. Value Eng. & Risk Mgmt.
Design Input
Technical Input
Program/ Constructi on Input
Preliminar y Design Report
Cost Plan & Cash Flow
Prepare Design Gateway approval paper
Sign Off
Sign Off
Sign Off
Sign Off
Sign Off
Sign Off (if appropriate)
End
Sign Off
Informed Finance
Doc. No. PM 0
Page 1/1
Rev. No. 00
Date: 01st August 2009

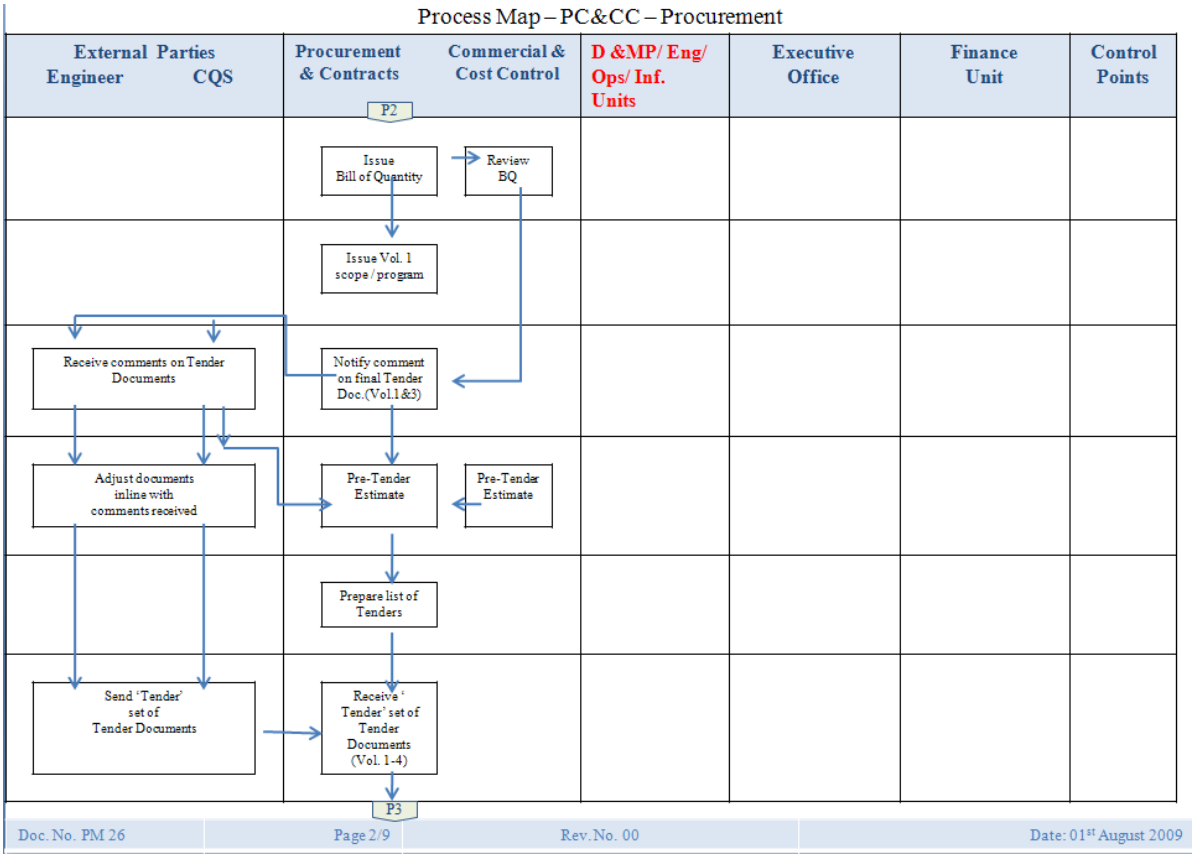
Process Map – PC&CC – Design Stage – Draft Final

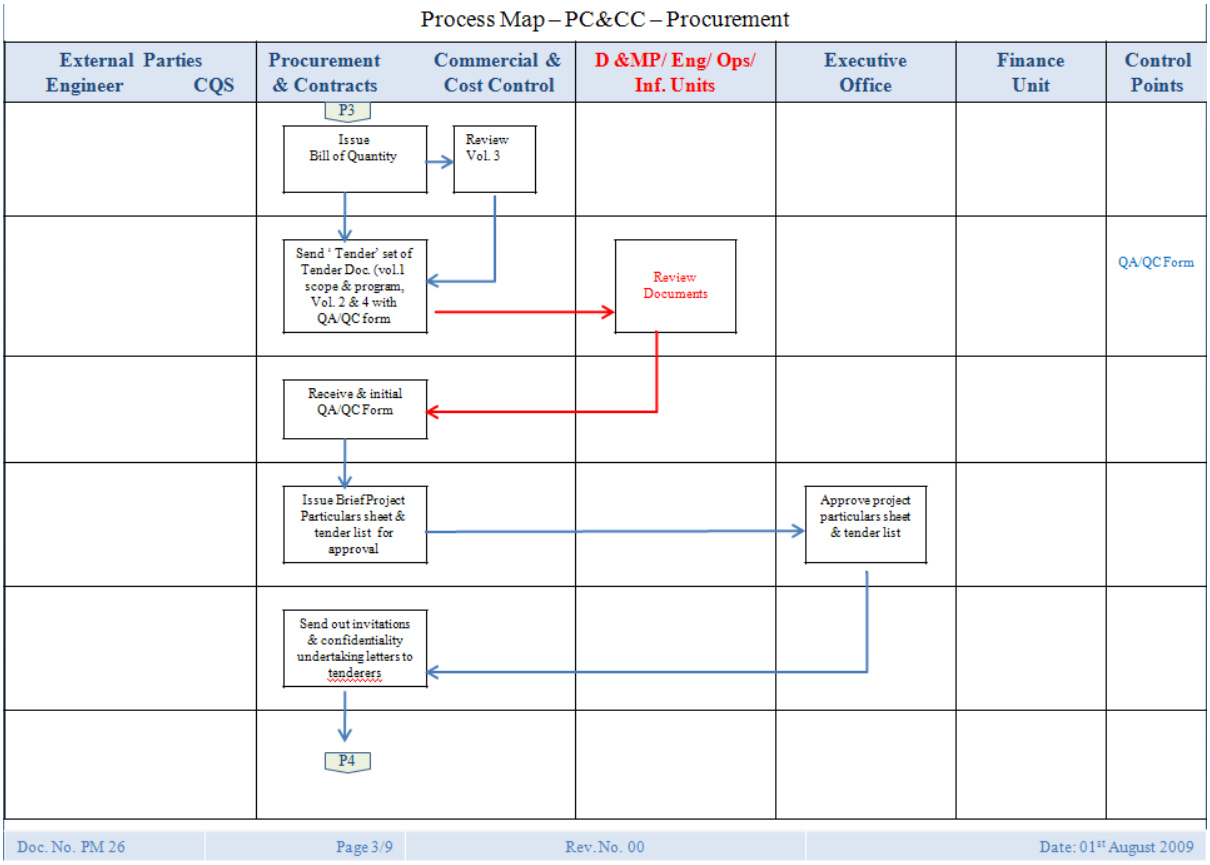


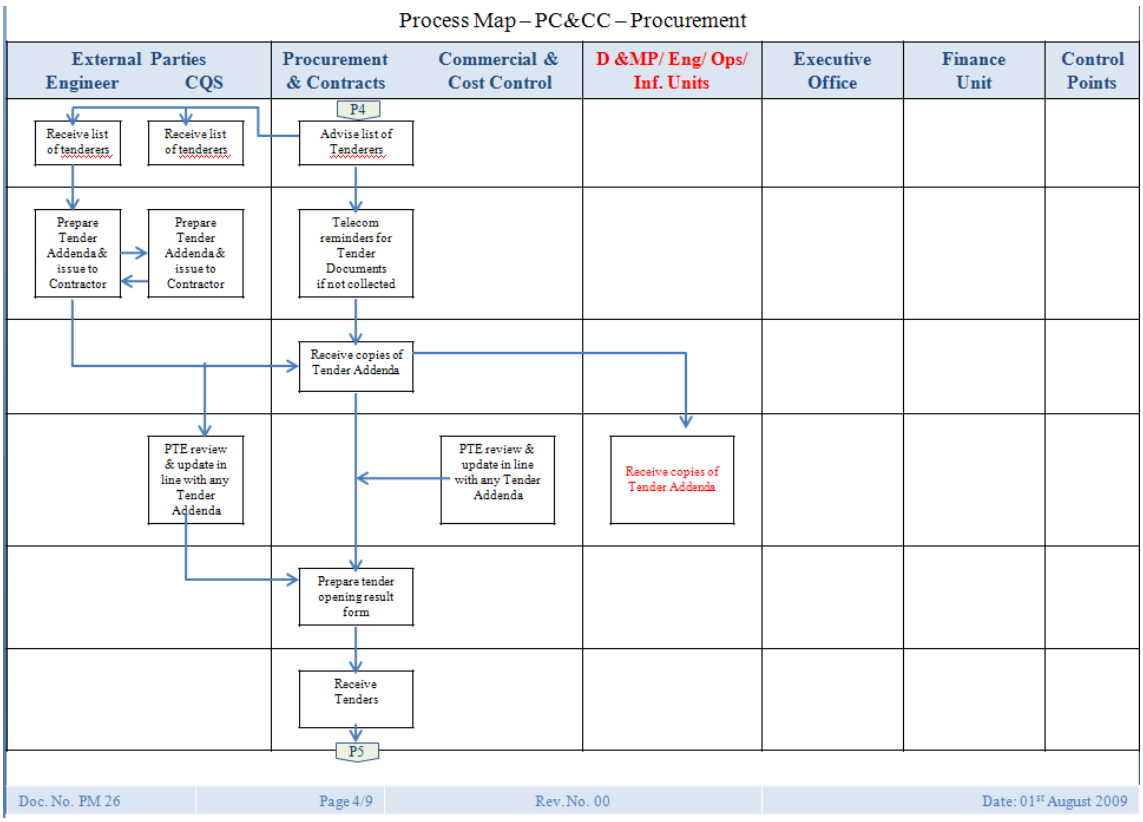
Process Map – PC&CC – Design Stage – Final

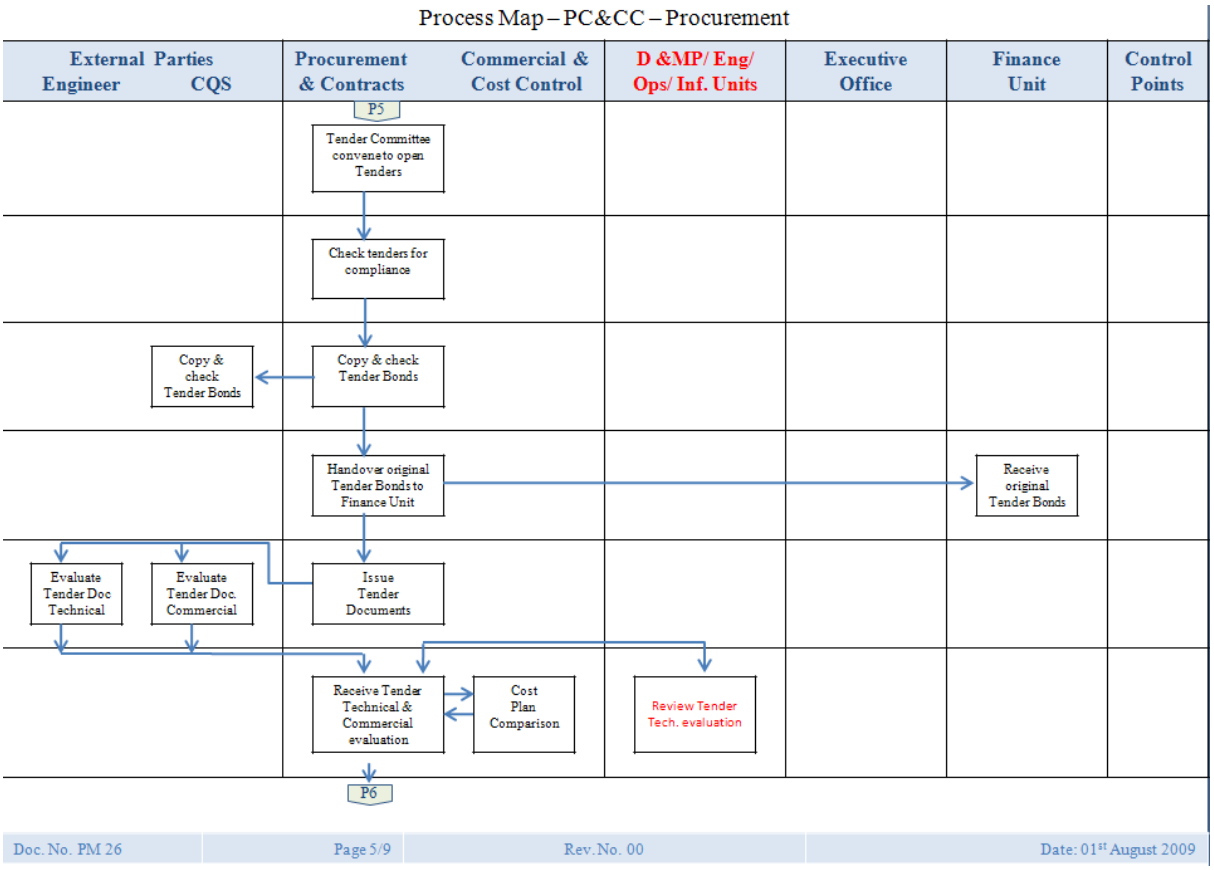


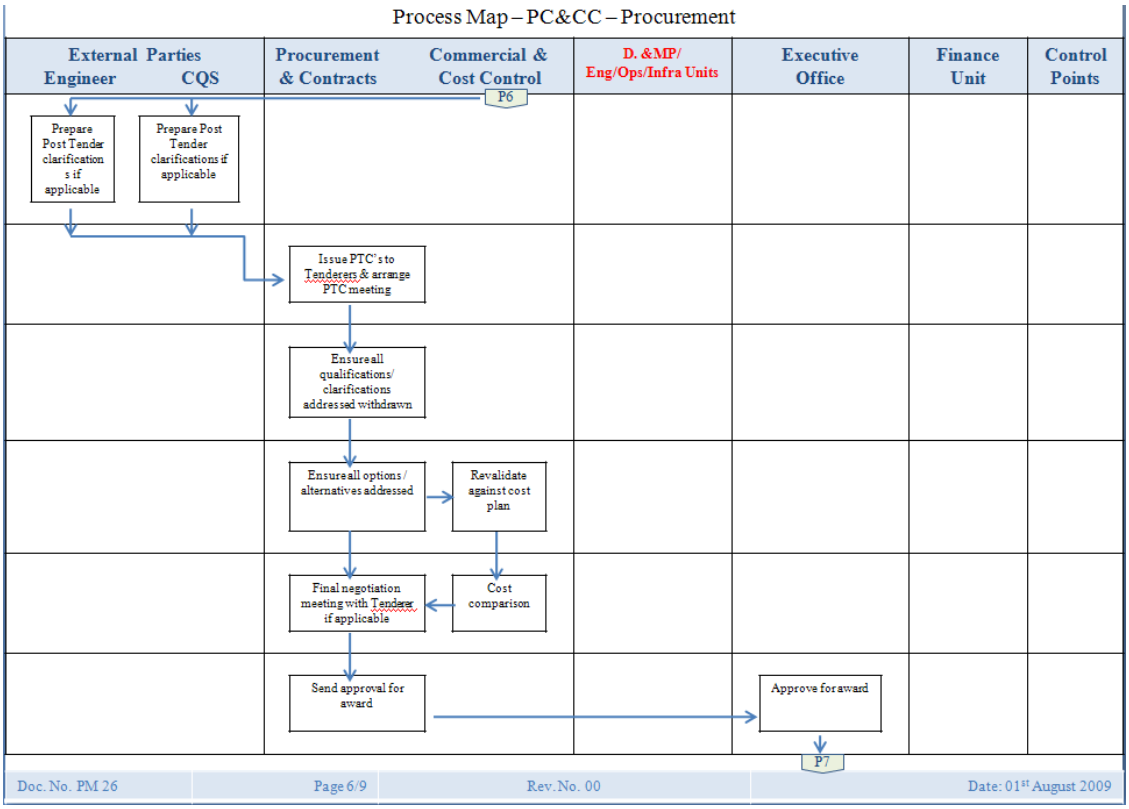

Process Map – PC&CC – Procurement
External Parties
Engineer
CQS
Procurement & Contracts
Commercial & Cost Control
D & MP/ Eng/ Ops/ Inf Units
Executive Office
Finance Unit
Control Points
Start
Receive Draft Final Tender Documents (Vol. 1 & 3)
Prequalify possible Tenderers if required *
Review & Comments
* Separate Process
Issue Bill of Quantity
Review BQ
BQ Review
Issue Vol. 1 scope / programme
Notify comment on draft final Tender Documents (Vol. 1 & 3)
Receive Comments on draft final doc.
Receive Comments on draft final documents
Receive final Tender Documents (Vol. 1 & 3)
P2
Doc. No. PM 26
Page 1/9
Rev. No. 00
Date: 01st August 2009

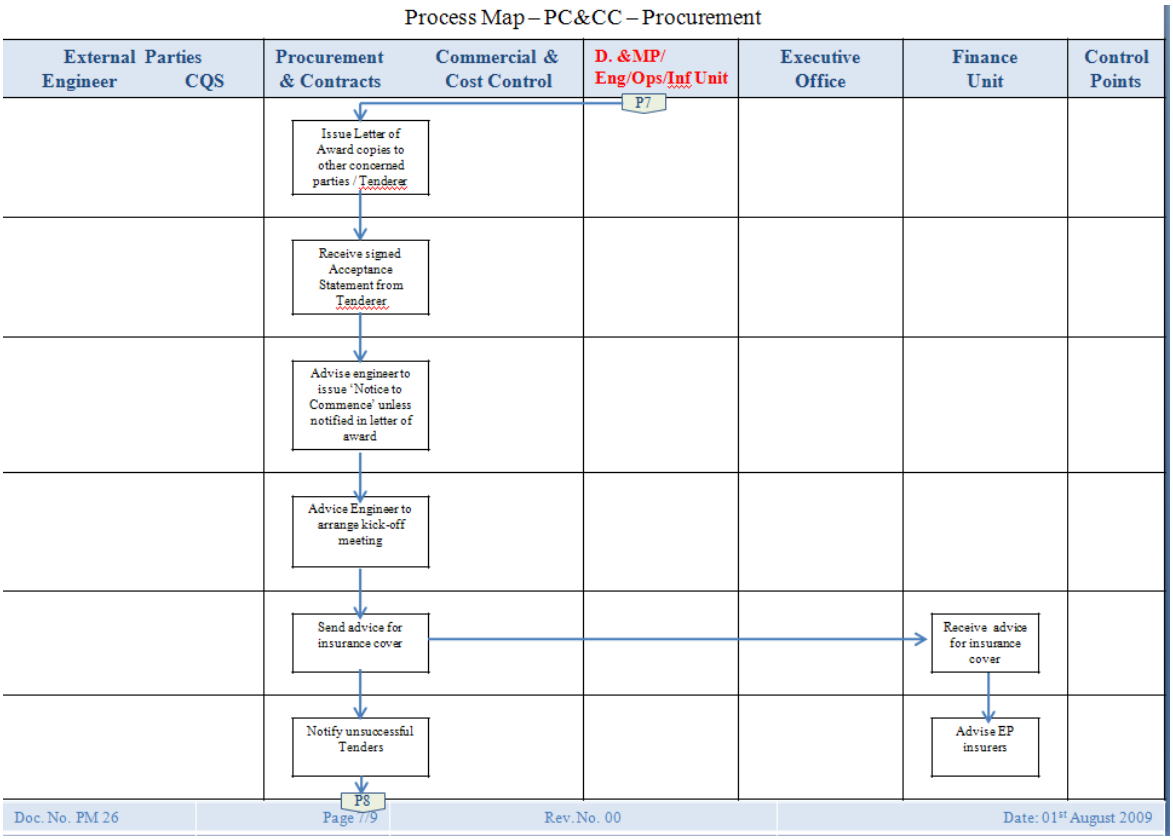

Process Map – PC&CC – Procurement
External Parties
Engineer
CQS
Procurement & Contracts
Commercial & Cost Control
D &MP/ Eng/ Ops/ Inf. Units
Executive Office
Finance Unit
Control Points
P2
Issue Bill of Quantity
Review BQ
Issue Vol. 1 scope / program
Receive comments on Tender Documents
Notify comment on final Tender Doc. (Vol.1&3)
Adjust documents inline with comments received
Pre-Tender Estimate
Pre-Tender Estimate
Prepare list of Tenders
Send 'Tender' set of Tender Documents
Receive 'Tender' set of Tender Documents (Vol. 1-4)
P3
Doc. No. PM 26
Page 2/9
Rev. No. 00
Date: 01st August 2009

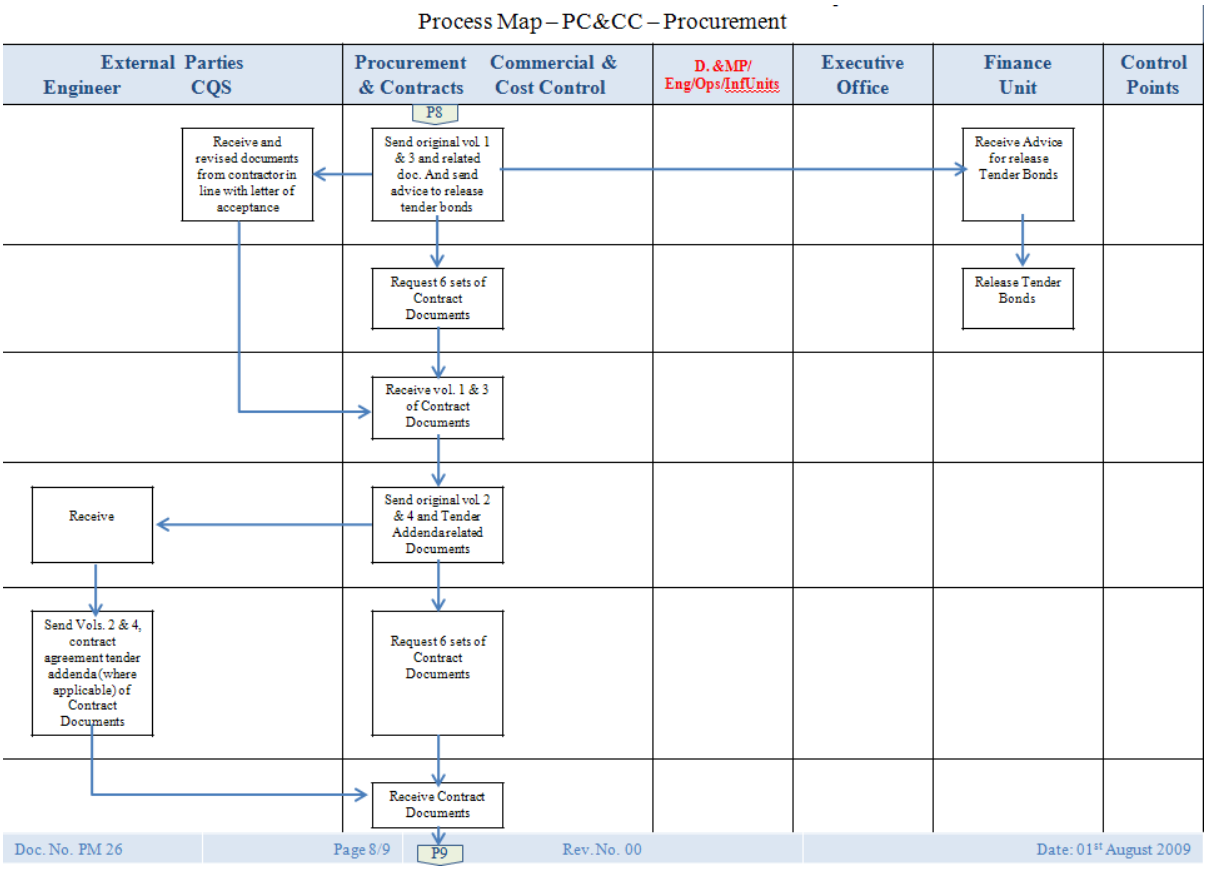

Process Map – PC&CC – Procurement
External Parties
Engineer
CQS
Procurement & Contracts
Commercial & Cost Control
D &MP/ Eng/ Ops/ Inf. Units
Executive Office
Finance Unit
Control Points
P3
Issue Bill of Quantity
Review Vol. 3
Send ' Tender' set of Tender Doc. (vol.1 scope & program, Vol. 2 & 4 with QA/QC form
Review Documents
QA/QC Form
Receive & initial QA/QC Form
Issue Brief Project Particulars sheet & tender list for approval
Approve project particulars sheet & tender list
Send out invitations & confidentiality undertaking letters to tenderers
P4
Doc. No. PM 26
Page 3/9
Rev. No. 00
Date: 01st August 2009


Process Map – PC&CC – Procurement
External Parties
Engineer
CQS
Procurement & Contracts
Commercial & Cost Control
D &MP/ Eng/ Ops/ Inf. Units
Executive Office
Finance Unit
Control Points
P4
Receive list of tenderers
Receive list of tenderers
Advise list of Tenderers
Prepare Tender Addenda & issue to Contractor
Prepare Tender Addenda & issue to Contractor
Telecom reminders for Tender Documents if not collected
Receive copies of Tender Addenda
PTE review & update in line with any Tender Addenda
PTE review & update in line with any Tender Addenda
Receive copies of Tender Addenda
Prepare tender opening result form
Receive Tenders
P5
Doc. No. PM 26
Page 4/9
Rev. No. 00
Date: 01st August 2009

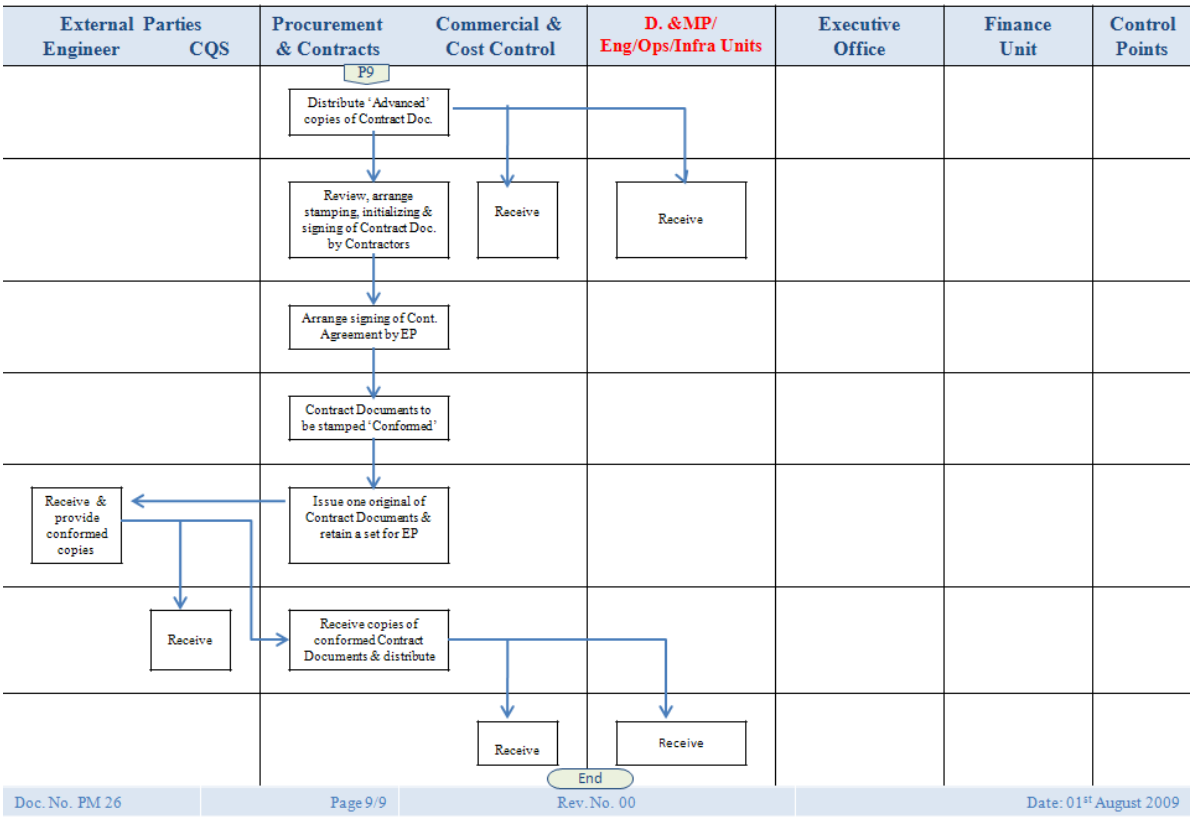

Process Map – PC&CC – Procurement
External Parties
Engineer
CQS
Procurement & Contracts
Commercial & Cost Control
D &MP/ Eng/ Ops/ Inf. Units
Executive Office
Finance Unit
Control Points
P5
Tender Committee convene to open Tenders
Check tenders for compliance
Copy & check Tender Bonds
Copy & check Tender Bonds
Handover original Tender Bonds to Finance Unit
Receive original Tender Bonds
Evaluate Tender Doc Technical
Evaluate Tender Doc. Commercial
Issue Tender Documents
Receive Tender Technical & Commercial evaluation
Cost Plan Comparison
Review Tender Tech. evaluation
P6
Doc. No. PM 26
Page 5/9
Rev.No. 00
Date: 01st August 2009


Process Map – PC&CC – Procurement
External Parties
Engineer
CQS
Procurement & Contracts
Commercial & Cost Control
D. &MP/ Eng/Ops/Infra Units
Executive Office
Finance Unit
Control Points
P6
Prepare Post Tender clarifications if applicable
Prepare Post Tender clarifications if applicable
Issue PTC's to Tenderers & arrange PTC meeting
Ensure all qualifications/ clarifications addressed withdrawn
Ensure all options / alternatives addressed
Revalidate against cost plan
Final negotiation meeting with Tenderer if applicable
Cost comparison
Send approval for award
Approve for award
P7
Doc. No. PM 26
Page 6/9
Rev.No. 00
Date: 01st August 2009


Process Map – PC&CC – Procurement
External Parties
Engineer
CQS
Procurement & Contracts
Commercial & Cost Control
D. &MP/ Eng/Ops/Inf Unit
Executive Office
Finance Unit
Control Points
P7
Issue Letter of Award copies to other concerned parties / Tenderer
Receive signed Acceptance Statement from Tenderer
Advise engineer to issue 'Notice to Commence' unless notified in letter of award
Advice Engineer to arrange kick-off meeting
Send advice for insurance cover
Receive advice for insurance cover
Advise EP insurers
Notify unsuccessful Tenders
P8
Doc. No. PM 26
Page 7/9
Rev. No. 00
Date: 01st August 2009


Process Map – PC&CC – Procurement
External Parties
Engineer
CQS
Procurement & Contracts
Commercial & Cost Control
D. &MP/ Eng/Ops/Inf Units
Executive Office
Finance Unit
Control Points
P8
Receive and revised documents from contractor in line with letter of acceptance
Send original vol. 1 & 3 and related doc. And send advice to release tender bonds
Receive Advice for release Tender Bonds
Request 6 sets of Contract Documents
Release Tender Bonds
Receive vol. 1 & 3 of Contract Documents
Receive
Send original vol. 2 & 4 and Tender Addenda related Documents
Send Vols. 2 & 4, contract agreement tender addenda (where applicable) of Contract Documents
Request 6 sets of Contract Documents
Receive Contract Documents
P9
Doc. No. PM 26
Page 8/9
Rev. No. 00
Date: 01st August 2009

Process Map – PC&CC – Procurement



Appendix (III): Agreed deliverables between Construction Authority and Consultant

Concept Design: That includes the following:

(a) General Analysis of existing site and conditions.

(b) Obtain drawings for all existing services from concerned authorities.

(c) Collect data, and study and provide analysis of passengers, aircraft and GSE traffic movement, and justify the design accordingly.

(d) Comprehensive brief, general layout and concepts design for the various facilities included in the project based on review of data provided.

(e) General analysis of all design criteria and concepts assisted by all the necessary diagrams, sketches and plans, together with alternatives and recommendations.

(f) An initial approach to the following: code analysis, structure, electromechanical, drainage, roads and finishes.

(g) Overall project programme of work up to completion.

(h) Initial Estimate and cash flow forecast.

(i) The project administrative and managerial proposed system related to proposed design.

(j) Preliminary functional area layout with associated facilities.

(k) Provide list of design parameters and assumptions considered.

(l) Summary of study report is to be prepared and individually submitted in the form of an executive summary.

(m) Analysis of the DCA's and other users' requirements.

(n) Code analysis.

(o) Proposed Architectural drawings in sufficient detail to demonstrate the design intent, together with alternatives.

(p) Structural and services drawings to approved alternative together with all the necessary details and calculations.

(q) Full set of mounted coloured presentation drawings, together with perspectives.

(r) Initial approach to required tender and contract documents in collaboration with the CQS.

Final Design

After Approval of the Concept Design, the Consultant proceeds with the Final Design and preparation of Tender Documents.

Final Design comprises detailed Tender Drawings, Specifications and other documents such:

(a) Final draft architectural design drawings including all locations and site plans, floor plans, sections, elevations and details.

(b) Final draft structural design drawings supported by calculations and to include all layout sections, elevations and details.

(c) Relevant data calculations, final soil investigation report and drawings relevant to engineering design.

(d) Final draft Services drawings including water supply, sewerage and storm water drainage (minor works only), irrigation, electrical and power lighting systems (internal and external) air conditioning, refrigeration and climatic control, telephone, telex, public address and security system, emergency electrical power, UPS, fire detection and protection system, solid waste collection and disposal system including all details; design drawings for all external works, including hard and soft landscaping, site boundary, site drainage, direction and information signs and power supply outlets for external use.

(e) Final draft Technical Specifications.

(f) Full set of "No Objection Certification" from all services authorities together with the estimated cost implications for final connections.

(g) Final draft Bill of Quantities.

(h) Final draft Tendering Procedures.

(i) Final draft Conditions of Particular Application in collaboration with the CQS.

(j) Building permits from concerned authorities.

(k) Final Cost Estimate.

Tendering stage:

During this stage, the Consultant prepares Tender Documents in collaboration with the CQS incorporating the CA review comments of the previous stage. These Tender Documents comprise:

3.1-Tender and Conditions of Contract (In collaboration with the CQS)

a) Instruction to Tenderers.

b) Form of Tender and Appendix to Contract.

The text of this is prepared by the Consultant in line with the specimen appended to the DCA Standard Conditions of Contract.

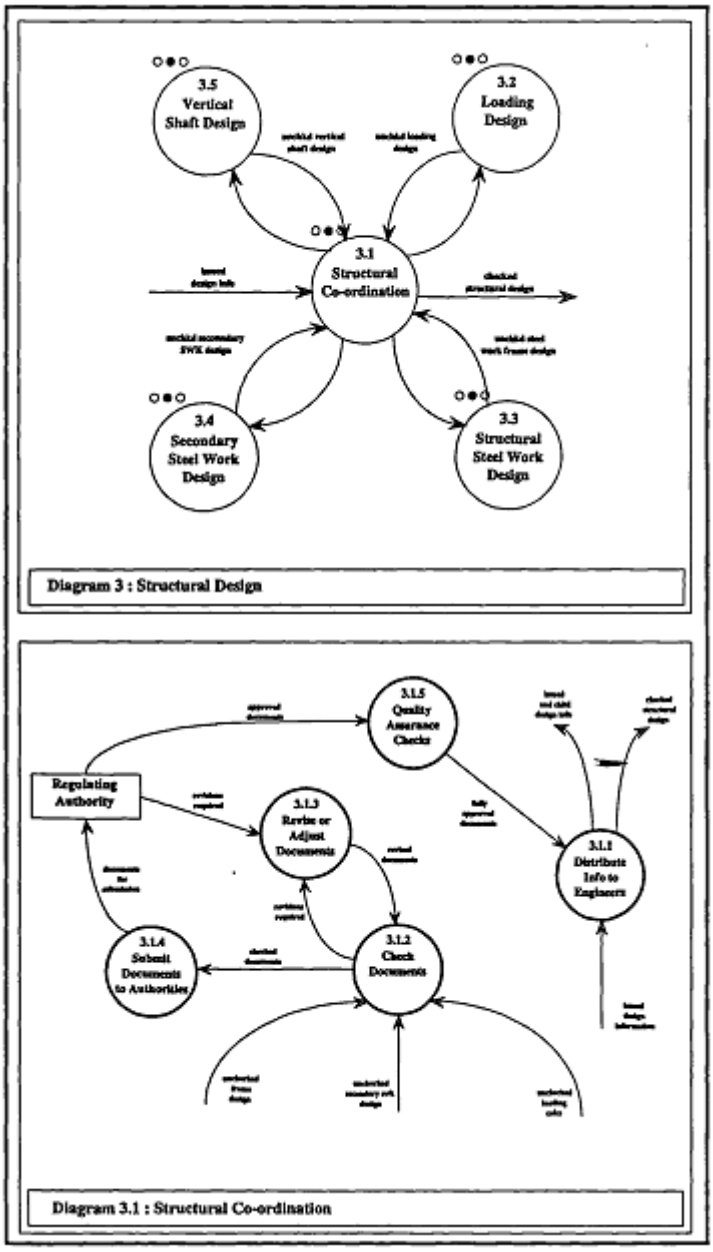
c) Conditions of Contract

i) Part I - General Conditions of Contract.

ii) Part II – Conditions of Particular Application.

In Addition to the above, the consultant is responsible for preparing the Specifications, Bills of Quantities which is prepared by CQS and Drawings.

Appendix (IV): DFD's example by Newton (1995)



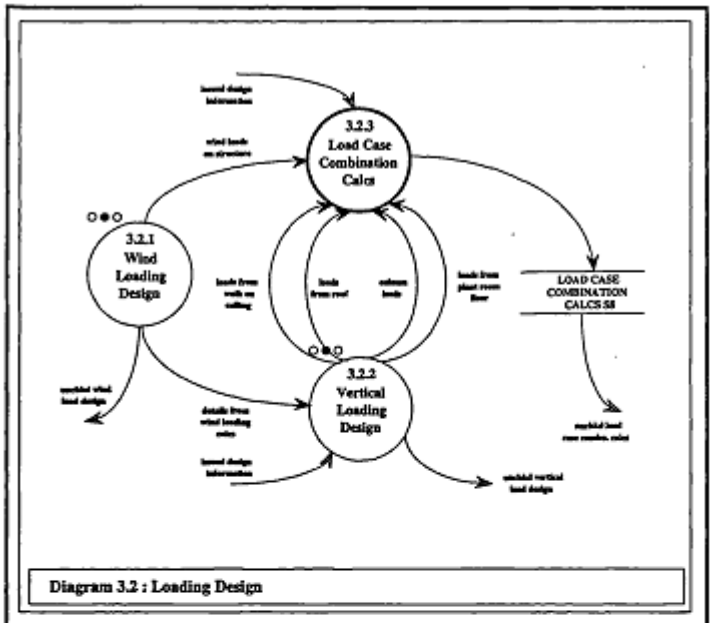


Diagram 3.2 : Loading Design

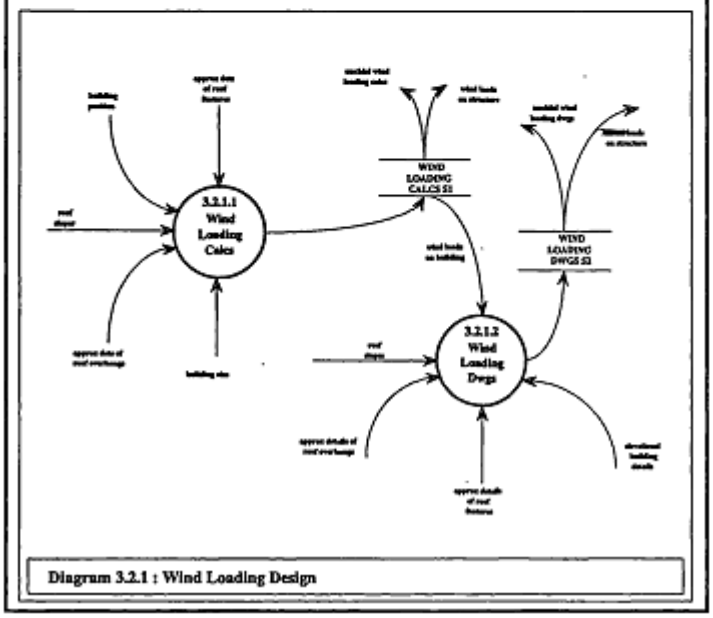


Diagram 3.2.1 : Wind Loading Design

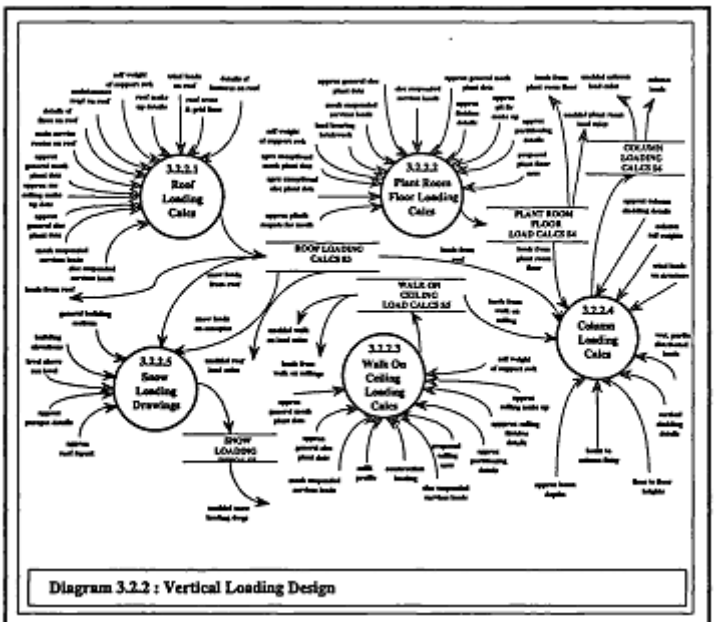


Diagram 3.2.2 : Vertical Loading Design

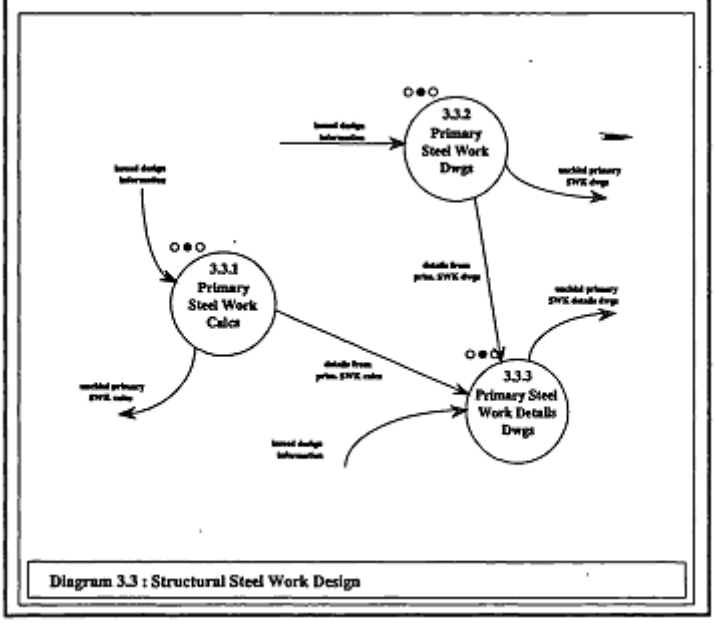


Diagram 3.3 : Structural Steel Work Design

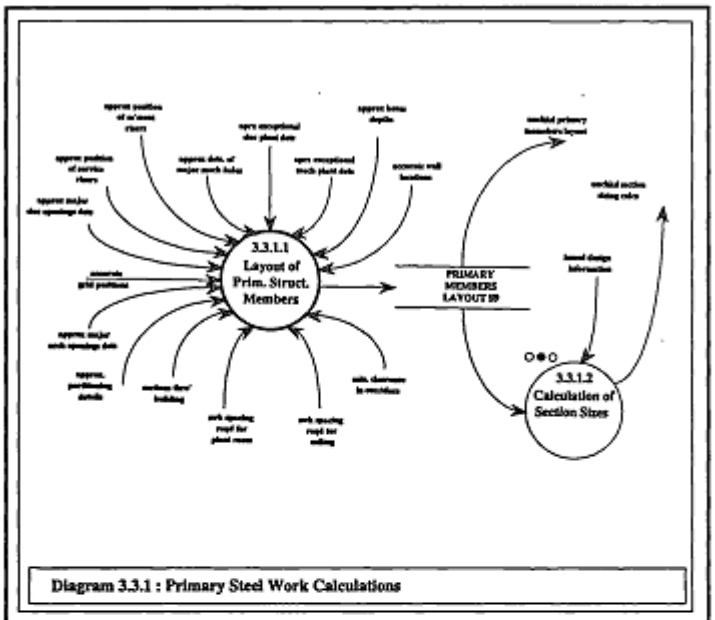


Diagram 3.3.1 : Primary Steel Work Calculations

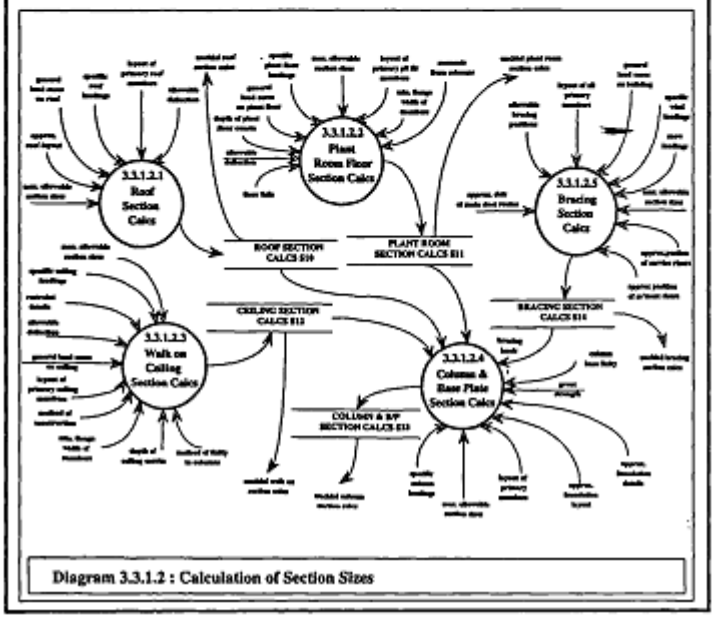


Diagram 3.3.1.2 : Calculation of Section Sizes

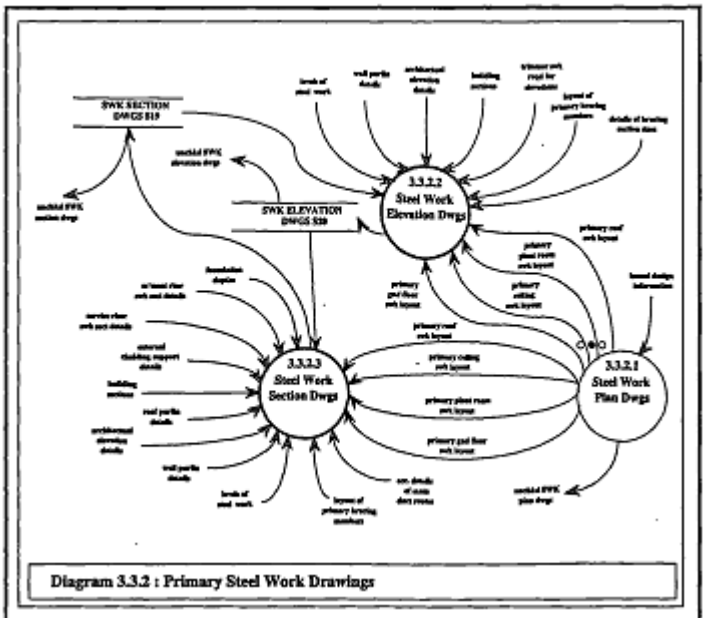


Diagram 3.3.2 : Primary Steel Work Drawings

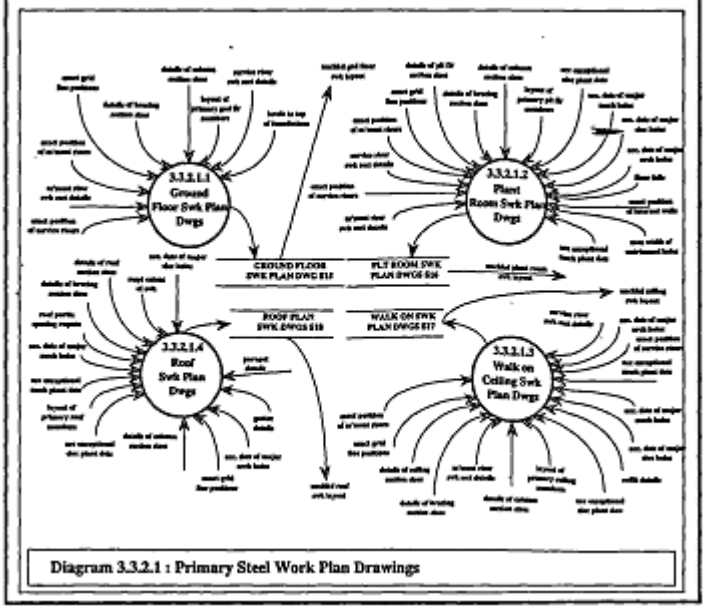


Diagram 3.3.2.1 : Primary Steel Work Plan Drawings

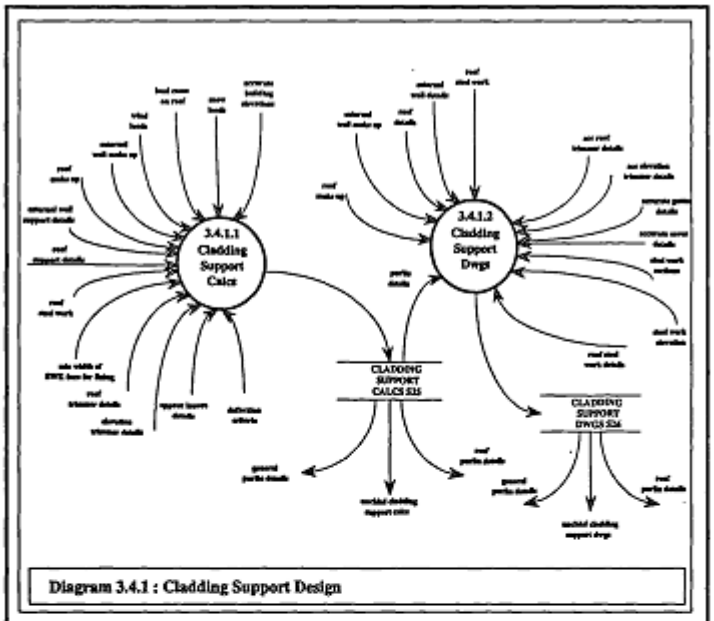


Diagram 3.4.1 : Cladding Support Design

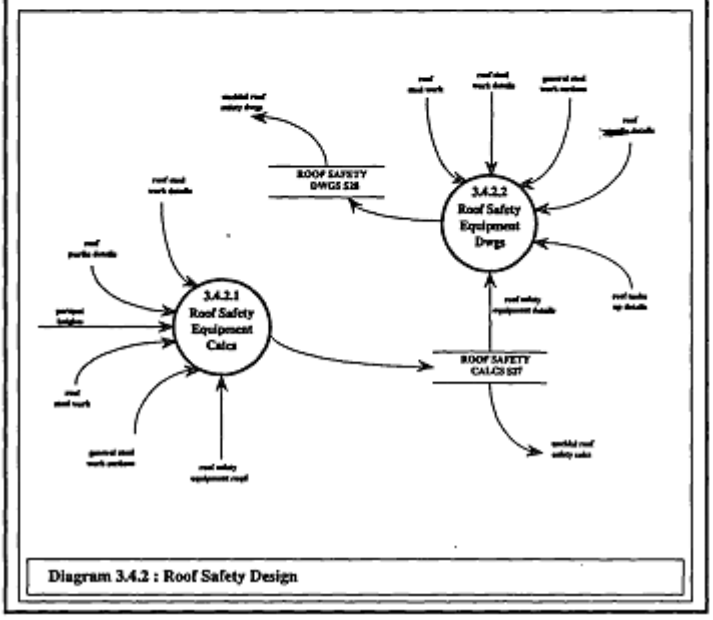


Diagram 3.4.2 : Roof Safety Design

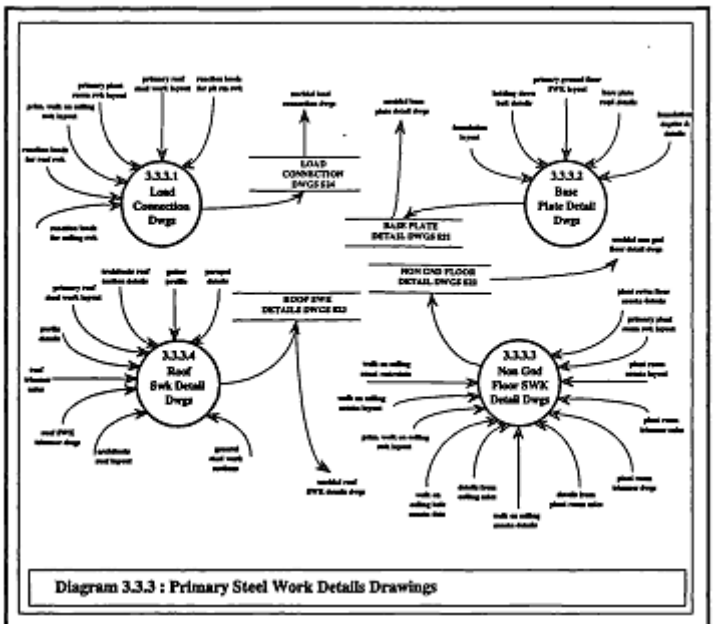


Diagram 3.3.3 : Primary Steel Work Details Drawings

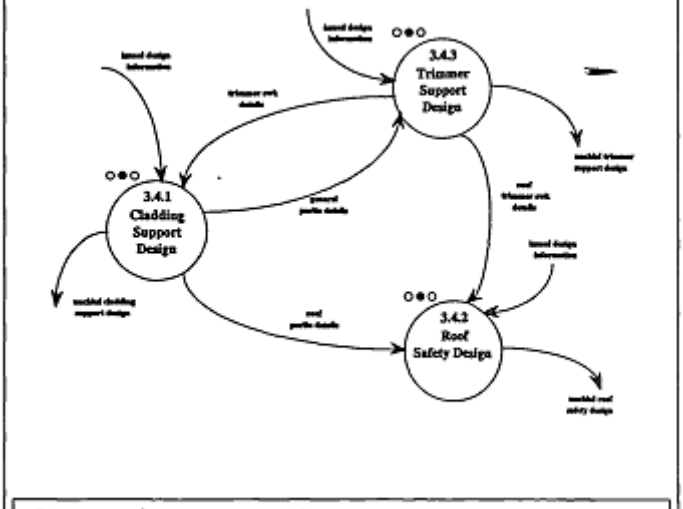


Diagram 3.4 : Secondary Steel Work Design

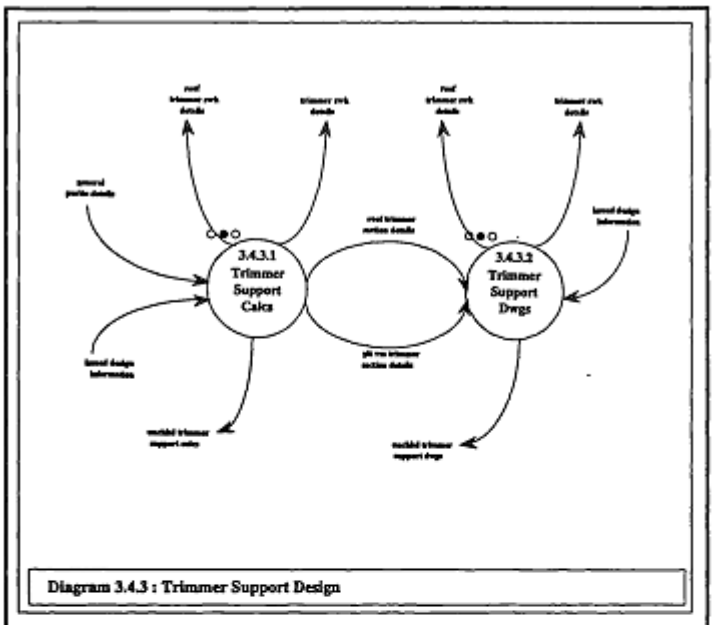


Diagram 3.4.3 : Trimmer Support Design

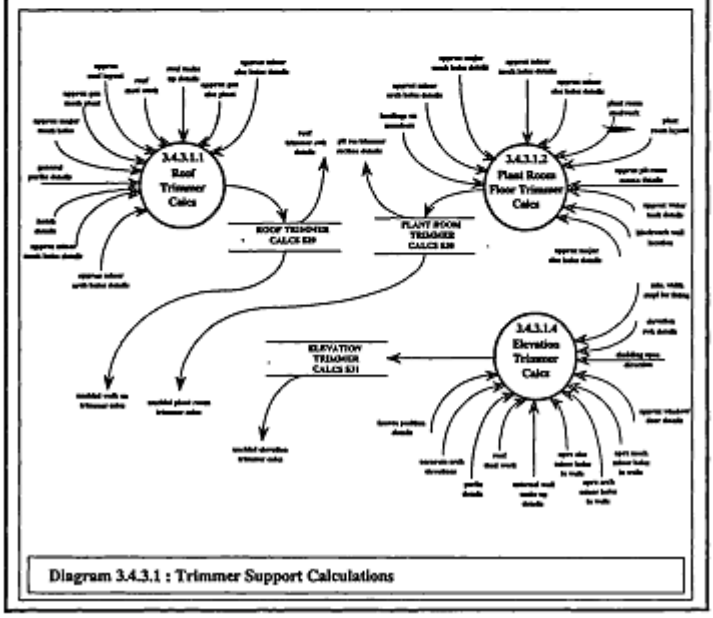


Diagram 3.4.3.1 : Trimmer Support Calculations

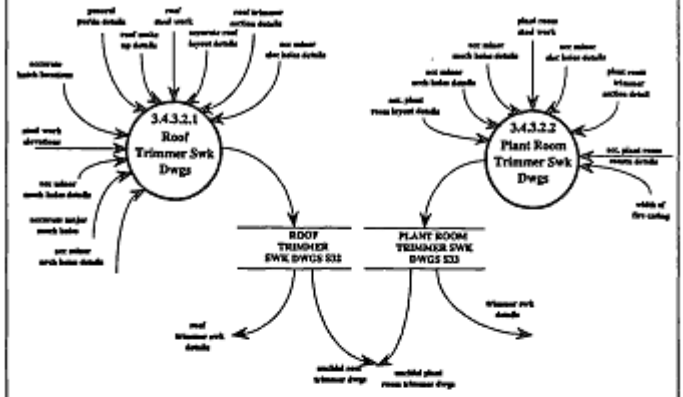


Diagram 3.4.3.2 : Trimmer Support Drawings

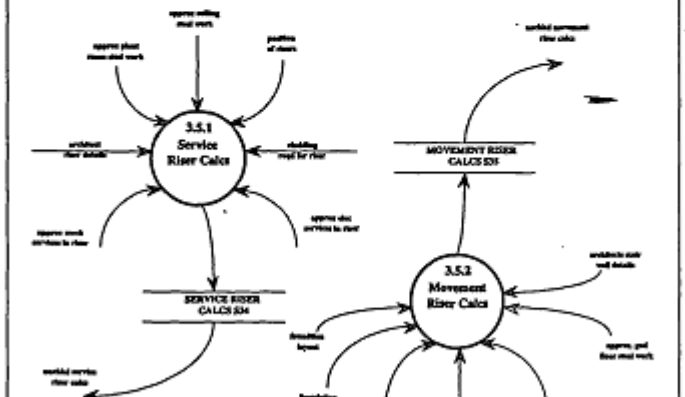
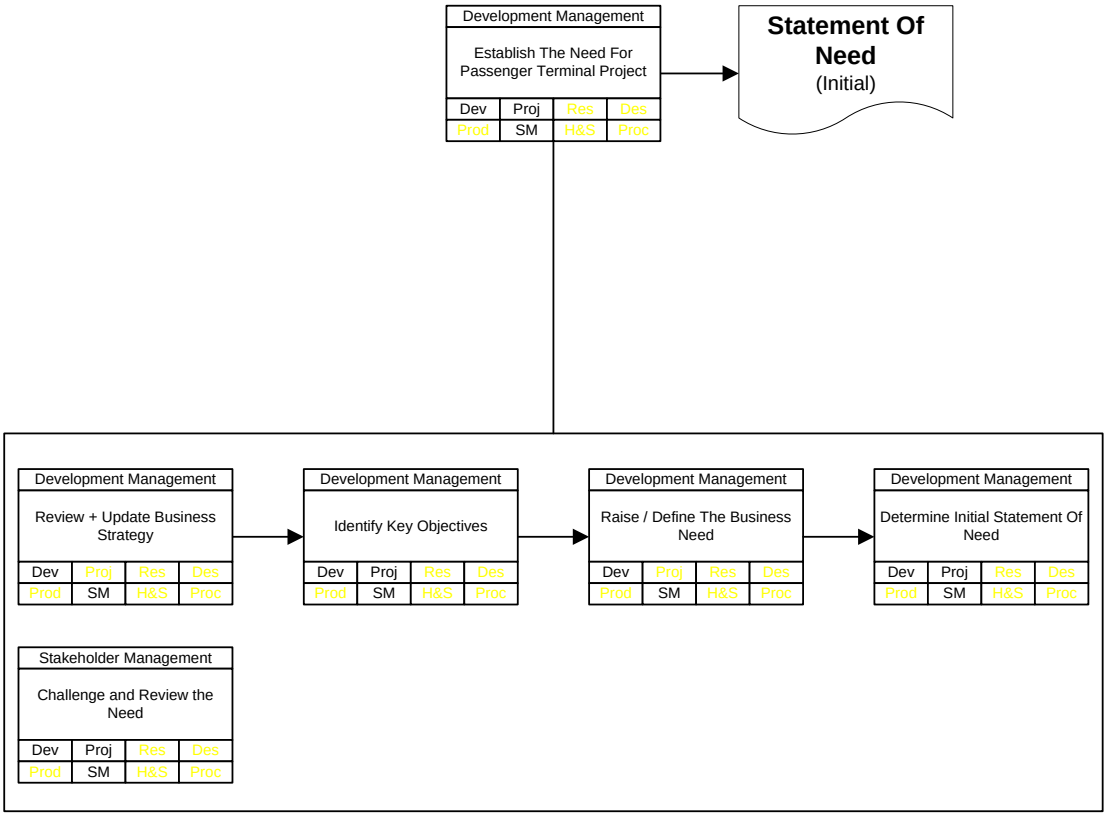


Diagram 3.5 : Vertical Shaft Design

Appendix (V): Level 2 activity zones (modified from Salford University 2002)

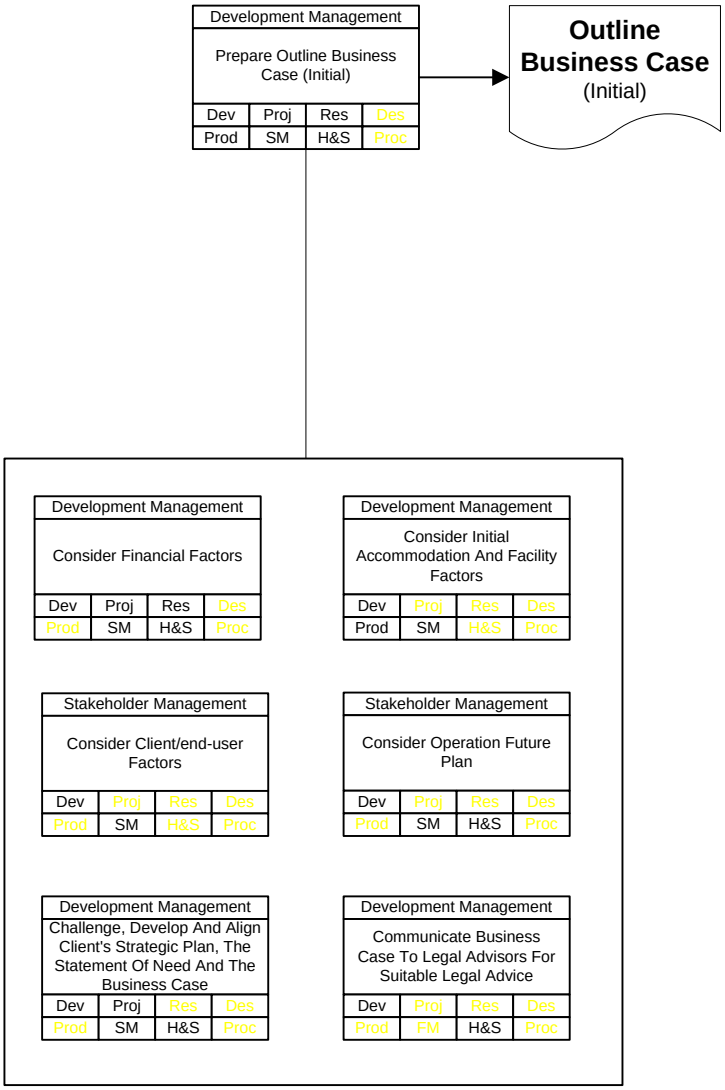
Phase 0: Demonstration of Needs

This stage will start by produce the statement of needs, the stage will be managed by Development Management, which will review and update the business strategy based on the input of Stakeholder Management discussion with different stakeholders, later the key objectives of the project will be identified along with the business need.

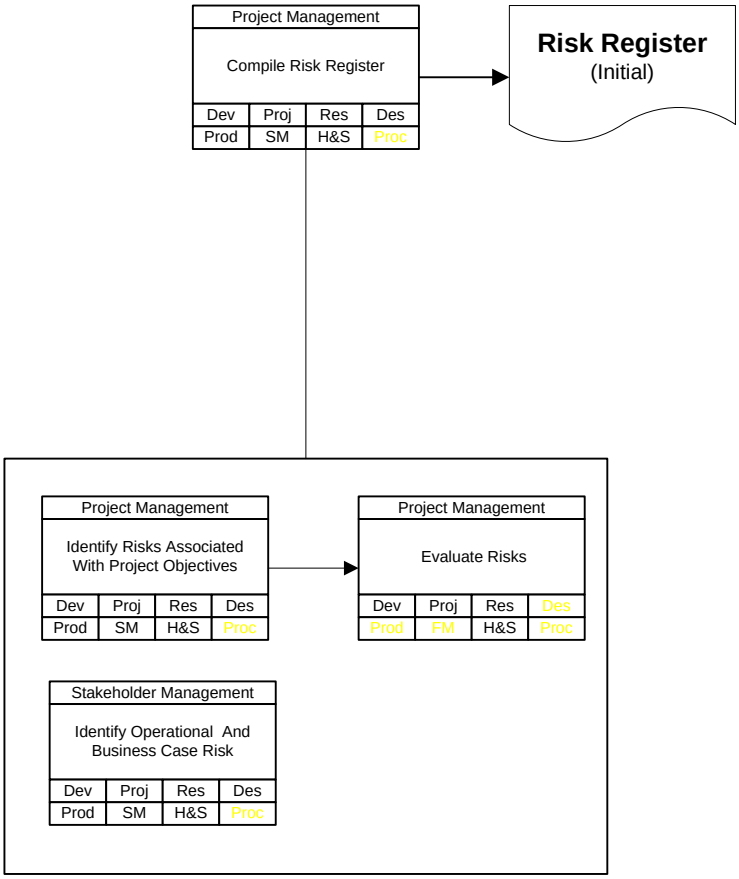


Next step will be outline Business Case,

Development management will consider financial factors, consider the initial design factors of the airport facility, challenge, develop and align client's strategic plan, and communicate business case for considering legal advisors for suitability. Stakeholder Management will be responsible for study the client's and end-user factors considering the future operation plan of the end-users.

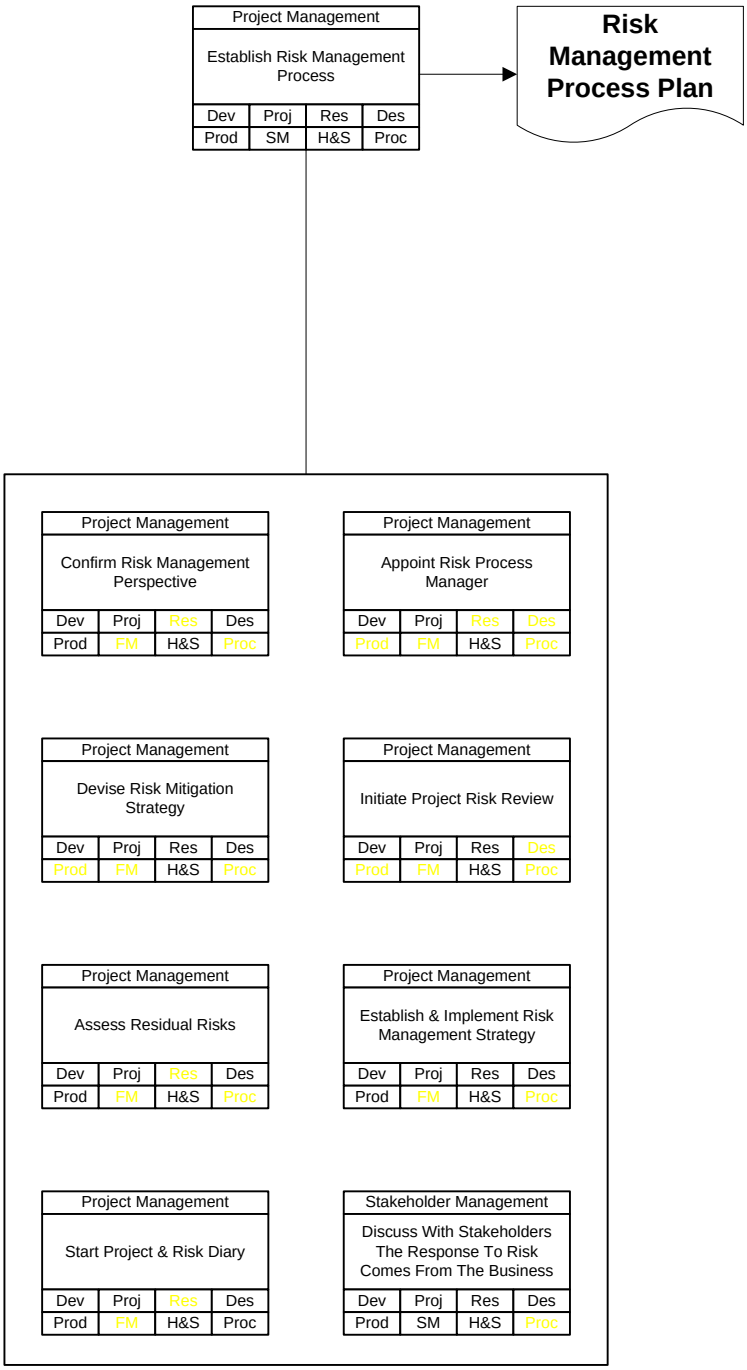


Next step will be compile risk register, it is suggested to be lead by Project Management according to Cooper et.al. (2005), the risk will be evaluated and identified, moreover, Stakeholder management will carry out the risks associated with portfolio of the airport beside operational and business risks, and will assess its impact on the business case.



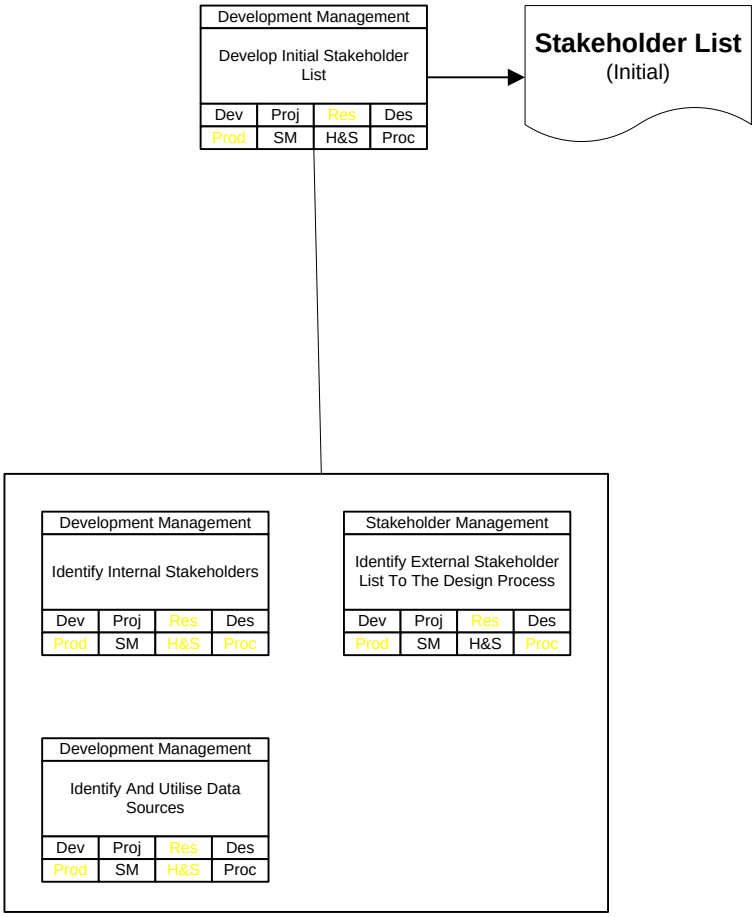
Next step will be develop Risk Management Process Plan, at this stage, project management will confirm the risk management perspective, appoint risk process manager, establish risk management strategy and start project and risk diary (University of Salfold 2002).

Stakeholder management will liaise with other stakeholder how to respond to the risk coming from the business plan, e.g. it is discussed that the airport terminal might be converted in the future from low budget airline to standard airline, this might impact the operational needs and facility size, hence it is mandatory to consider how to response to such change in the future, and this can be achieved through developing a strategy with airport stakeholders in order to address such issue.

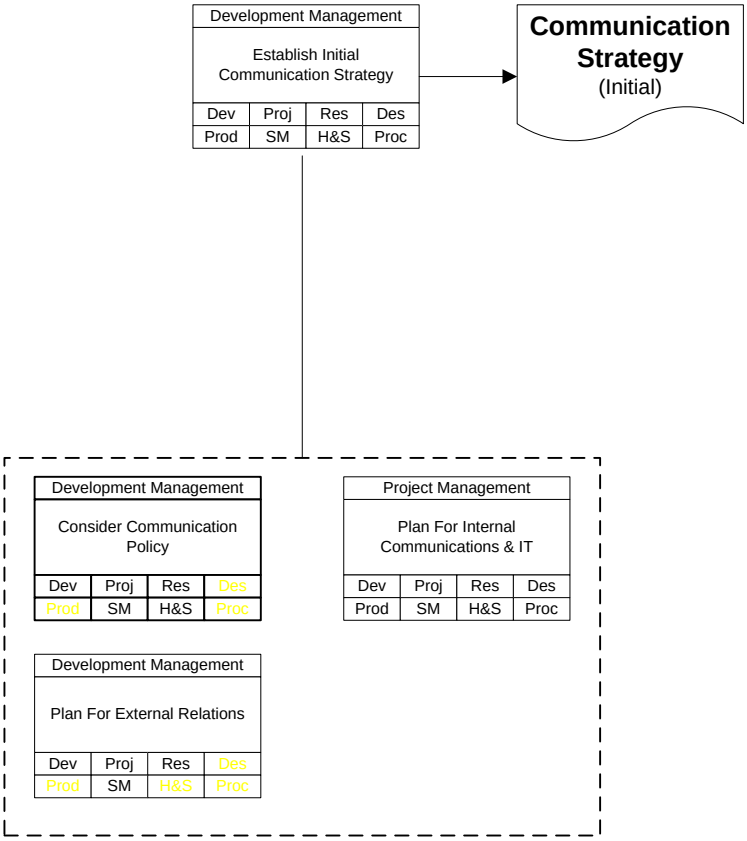


Next step will be identify Stakeholder list, this exercise is carried out by development management , University of Salfold maps (2002) did not involve facility management in this process, from Airport design point of view, It is important to involve the Facility management team which is Stakeholder management as proposed by this research in this exercise, since they will be responsible for coordination with external stakeholders to the project, while

development management will be responsible for the internal stakeholder list development.

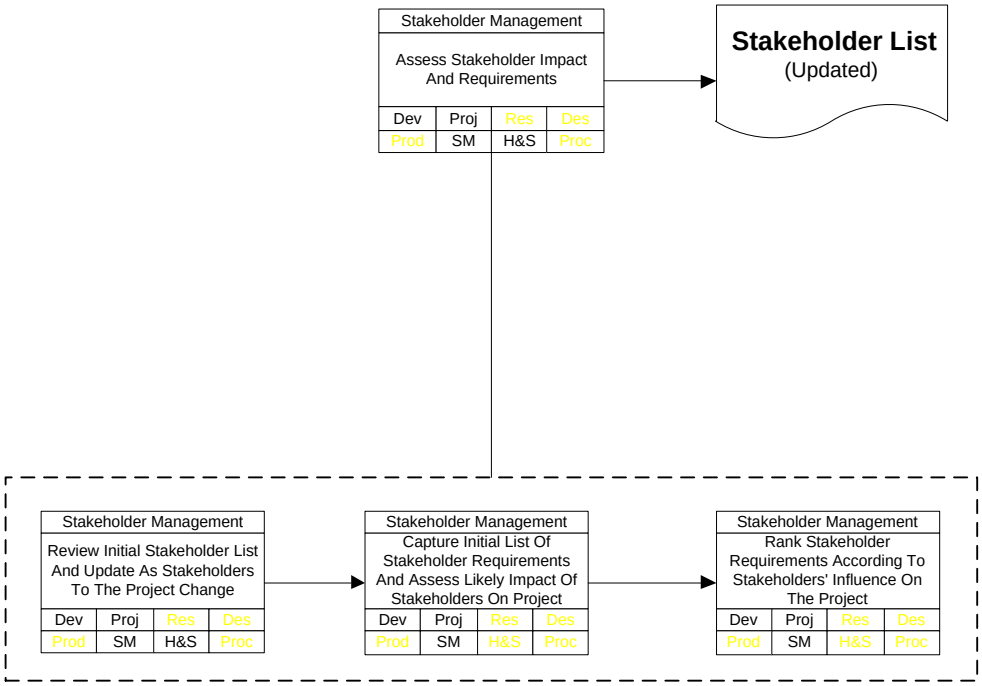


Next step will be establishing the communication strategy, development management is responsible for establishing this strategy, it is important to highlight the importance of IT software proposed by Cooper et al. (2005) to be extended to cover the external stakeholder to the design process, Stakeholder management will be responsible for such coordination with external parties, and it might be seen from this research point of view, that this software should be easily used with external stakeholders who are not involved thoroughly in the design process, e.g. it is expected that this software will target the correct stakeholder which is identified by Stakeholder Management and will introduce to that particular stakeholder the recent design decision and will ask that stakeholder to answer certain questions addressed by the designers. Such strategy requires further development with IT department in order to integrate such idea.

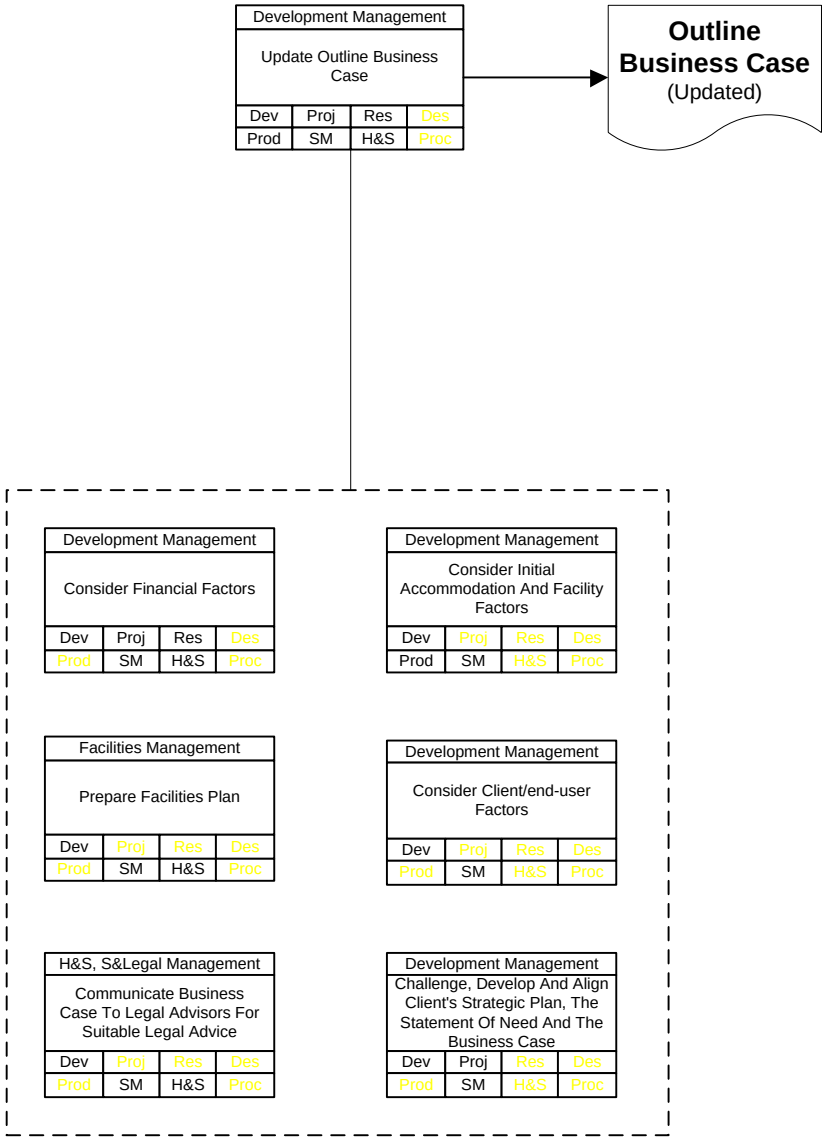


Phase 1: Conception of Needs:

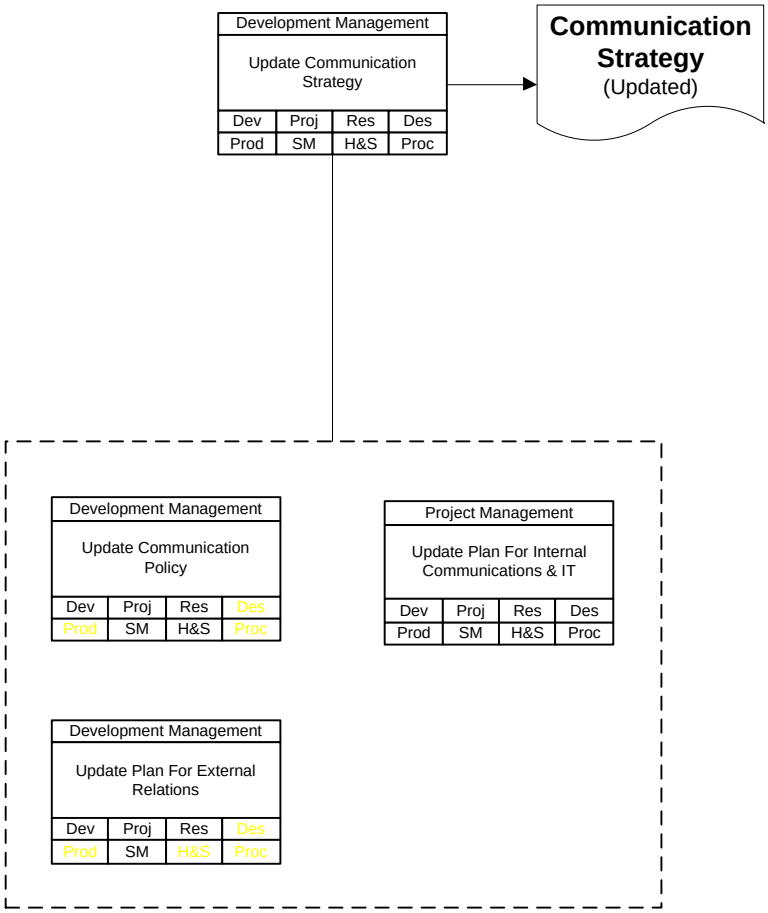
Based on the previous stage findings, stakeholder list will be updated, this activity will be lead by Stakeholder Management team, SM team can use the proposed tools presented earlier in order to assess stakeholder power – interest and develop a strategy for handling their requirement.



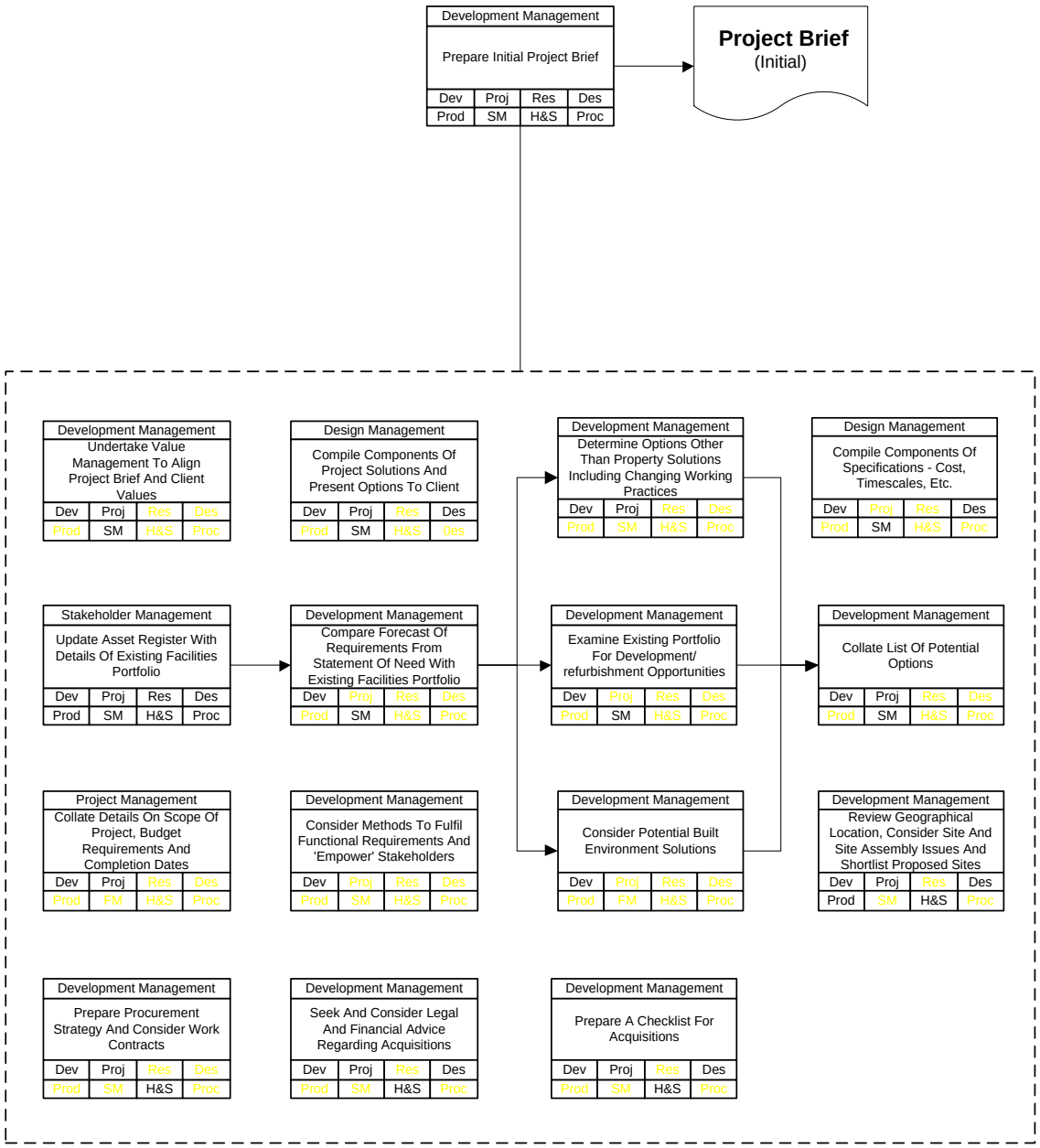
Next stage will be updating the Business Case outline.



Later Communication strategy will be developed



Next step will be developing project brief



Next steps will be develop feasibility design brief, Update initial risk register and develop risk management process plan, detailed discussion is not required since it does not involve stakeholder management activity zone.