

**ACTIVITY-BASED LIFE CYCLE COST PROCESS MODEL OF
FACILITIES MAINTENANCE FOR PUBLIC UNIVERSITIES**

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ACTIVITY-BASED LIFE CYCLE COST PROCESS MODEL OF FACILITIES
MAINTENANCE FOR PUBLIC UNIVERSITIES

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This thesis is dedicated to my family for their endless support and encouragement

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ABSTRACT

Facilities maintenance is an essential part in the whole process of building maintenance and management. Maintenance period spans through the life cycle of a building hence, more attention is required in terms of financial management and good recording keeping. The application of life cycle cost in facilities maintenance is still limited caused by the complexity and variation of assets. The study develops the Activity-based life cycle cost process model for public universities (Research Universities) in Malaysia in order to provide an effective cost management in building facilities maintenance. Data for the study was based on a questionnaire survey and interview granted by some senior maintenance officers and experts in the building industry. Findings from the study show that the institutions varied in the level of importance they attached to the various facilities in a building in terms of financial allocation for maintenance. Those facilities that have been accorded much priority based on the results from the study were used in developing a process model of Activity-Based Life Cycle Cost (AB-LCC) of facilities maintenance at public university. The findings show that the AB-LCC process model was defined clearly across every facility maintenance activities with the clarity of cost drivers. Aggregating all activities together under a unit during the financial allocation does not give room for accountability and efficiency in building maintenance of public universities in the country. The application of AB-LCC has policy implication for both government and public universities because of the competing needs they will face with and the need to allocate resources in a way that the desired result would be met.

ABSTRAK

Penyelenggaraan fasiliti adalah satu bahagian penting dalam proses keseluruhan pengurusan dan penyelenggaraan bangunan. Tempoh penyelenggaraan menjangkau melalui kitaran hayat sebuah bangunan oleh itu, perhatian yang lebih diperlukan dalam bidang pengurusan kewangan dan dokumentasi yang baik. Aplikasi kos kitaran hayat dalam penyelenggaraan fasiliti masih terhad disebabkan oleh kerumitan dan variasi aset. Kajian ini membangunkan model proses kos kitaran hayat berasaskan aktiviti untuk universiti awam (universiti penyelidikan) di Malaysia bagi menyediakan cara pelaksanaan pengurusan kos yang efektif. Data untuk kajian ini adalah berdasarkan tinjauan soal selidik dan temu bual yang diberikan kepada pegawai-pegawai kanan bahagian penyelenggaraan dan pakar dalam industri pembinaan. Penemuan kajian ini menunjukkan bahawa institusi yang berbeza mempunyai tahap kepentingan berbeza terhadap pelbagai fasiliti bangunan daripada segi peruntukan kewangan penyelenggaraan mereka. Fasiliti yang telah diberi lebih keutamaan berdasarkan hasil daripada kajian telah digunakan dalam membangunkan model proses Kos Kitaran Hayat Berasaskan Aktiviti (AB-LCC) bagi penyelenggaraan fasiliti di universiti awam. Penemuan kajian menunjukkan model proses kos kitaran hayat berasaskan aktiviti telah dibangunkan dengan teliti dengan mengambilkira kesemua penyelenggaraan fasiliti dengan *cost driver* yang jelas. Dengan memasukkan sekaligus semua aktiviti bersama-sama di bawah satu unit aktiviti dari segi peruntukan kewangan tidak akan memberi ruang untuk akauntabiliti dan kecekapan dalam penyelenggaraan di universiti awam. Penggunaan konsep AB-LCC mempunyai implikasi ke atas dasar kerajaan dan universiti-universiti awam kerana mereka akan berhadapan dengan keperluan bersaing dan juga keperluan untuk memperuntukkan sumber dengan cara yang mana keputusan yang diinginkan akan dipenuhi.

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LIST OF SYMBOLS

<i>LCC</i>	-	Life cycle cost
<i>ABC</i>	-	Activity Based Cost
<i>AB-LCC</i>	-	Activity-based life cycle cost
<i>RU</i>	-	Research University

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CHAPTER 1

INTRODUCTION

1.1 Background of Research

Malaysian education system covers education from pre-school to university, under the jurisdiction of the Ministry of Education (MOE). Previously, the education system was branched under two ministries, where pre-tertiary education is under the jurisdiction of the Ministry of Education (MOE) while tertiary education or higher education is directly under the jurisdiction of Ministry of Higher Education (MoHE). For the past few decades, Higher Education in Malaysia is a sector that grow enormously and Malaysia becoming a centre of educational excellence in the region. The government is committed to make Malaysia as an education destination and hub for citizen around the world. “Strategic Plan for Higher Education: Laying the Foundation Beyond 2020” launched in an attempt to measure and strategizes Malaysian education system towards an international centre of education excellence.

Education plays an important role in Malaysian Strategic Plan. Education sector detail descriptions are included in Malaysian Plan which developed every five year as the Malaysian government national development initiative by outlining its values, policies and implementations. Allocation provided to this sector is the highest national development budget and increases every year and that shows the government’s concern on improving and developing education sector as this is one of the major field that contributes in producing intellects in the country. Malaysian

higher educational institutions aim to develop centre of knowledge and also to generate individuals that are competent and innovative to serve the nations and global needs.

Under the Eighth Malaysian Plan, allocation for higher education institutions was RM8, 900 million (Government of Malaysia, 2001), whereas under the Ninth Malaysian Plan the allocation raised to RM16, 069 (Government of Malaysia, 2006). It is clearly stated that the allocation from Malaysian government for the public higher educational institutions increase dramatically after five years. Based on the government's Tenth Malaysian Plan, RM10, 200 billion has been allocated for higher education ministry out of RM29, 300 billion that was allocated for the education sector by the government (Government of Malaysia, 2010). This amount is still considered as a big amount of allocation in the government sector because higher education has to bear on the knowledge-based economy (k-economy) and its benefits towards the country. In realising this transformation plan, each top tier of higher education institution must fully understand their institutions' vision and mission and meet their expectations in achieving the core business needs. At operational level, higher education institutions are responsible to recognise and identify the important elements that contribute to the core business and its support functions. Besides, developing activity such as commercialisation of Research and Development (R&D) and fundraising, cutting down avoidable expenditures through a good management can also be a supportive function in contributing monetary vice.

Universities are part of higher education institutions that conduct strong academic programs to fulfil the nation's and region's education needs. A growing desire to develop knowledge-based economy is to enhance competitiveness. In achieving this aim, universities require a well-trained and innovation minded workforce, development of information and communication, well-maintained infrastructure, policies and also research and development activities. University buildings play an important role in producing suitable and adequate internal and external environment that support and regulate teaching, learning and research and development process. University buildings also play a paramount role in the provision of quality education. Various types of building and usage exist in universities such as lecture halls or classrooms, faculty offices, multi-purpose hall,

restaurant or cafeteria, sport complexes and etc. Thus, deficiency in the delivery of building facilities service will negatively impact universities to achieve its objective besides causing loss in value not only to the university but also to the users and others. In that case, maintenance of those buildings is very important.

According to Ishak (2006), maintenance management of university buildings are based on planned maintenance, contingency service, routine and preventive maintenance and corrective maintenance. Ruslan (2007) mentioned that even, most of the Malaysian universities are still maintaining their building facilities maintenance in a traditional way which is through corrective or reactive and condition based. Corrective or reactive based maintenance is done after the building is identified as failed to perform at its best and needed to be restored in order for the building to be back to its original condition. Maintenance involves corrective maintenance procedures as a major approach may lead to uncontrollable excess in maintenance costs and expenditures for the universities as corrective maintenance are expensive in many cases. While, condition based maintenance is done through proactive and predictive maintenance. Maintenance undertaken according to the buildings specifications and physical conditions and as long as the building fulfil these both criteria, there will be no maintenance activities carried out for the particular building (Idrus et al, 2009).

In the Malaysian context of university building facilities, budgeting would be the vital practice in this country as in general the maintenance cost in managing building facilities, especially public universities, are becoming more expensive. Systematic approach in maintenance of buildings facilities could result in cost saving for public universities. Synchronize to that need; life cycle cost analysis to the public universities buildings will be expanded to study on, in order to provide an conceptual understanding of life cycle costing application and on the benefits of its implementation through a cost-effective approach in decision making process and cost management of public university building facilities maintenance.

1.2 Problem Statement

Facilities management is based on business activity and responsive to changes in clients' needs according to time and cost effective manner (Then and Tan, 2006). For many organizations, the effectiveness of their cost delivery is considered as an important component and the profession of facilities management continues to evolve to reflect this. Business needs is a fundamental issue in the application of facilities management knowledge to achieve business performance (Then and Tan, 2006). Gunasekaran (1999) mentioned that one important factor to determine customer profitability is cost of product or service purchased. Even though there are several other factors but cost can be highlighted as a basic preference in satisfying clients. Whereby, according to Then and Tan (2006), facilities management is a real support service. Thus, costs are an advantage in service delivery and management in satisfying the service receivers.

The public university ought to care about facilities planning and business performance due to the fact that they are important and necessary parts of the entire service delivery process and it comprehend how well the facilities function is. Due to the fact that a lot of things change within and outside an organization over time, a facilities plan that seems optimal today will probably have a number of shortages after a few years, this means that facilities planning and measurement are a continuous work. This depends on the services which will probably change in many ways for example the changes in university demands (e.g. students, faculty members, admin staffs and etc), the design of the services, development of new services and etc. Increase in technology enhancements, market condition, demand for innovation and decreasing in life cycles result in public university to be more concern on continuously re-adjusting, re-aligning their operation to foresee all these challenges. These changes are insistent in estimating future cost. Therefore the facilities planning and the business performance will be a continuous process in an organization and it should be viewed from a life cycle perspective.

As mentioned by Singh and Tiong (2005), infrastructure assets are the basic features that reflect a nations' economic strength. This goes the in a same way for a university building, the operation and maintenance reflect the economic strength of a

building. Malaysian government has followed the global trend and introduced major reforms in order to be able to play an effective role in various fields of public management by adopting pro-market values like efficiency, productivity and cost-effectiveness in business of the government. Besides that, a variety of changes have been introduced such as physical facilities, improved equipment and so on (Siddiquee, 2006). Consequent introduction and reformation to improve and upgrade the public sector, has emerged a need for public university building services and management dramatically. As we know, government assets are huge ownership of the country and it has to play a good role in providing services accordingly. Consequently, operational management play an important role in this matter. In the top level factors in a facilities management strategic plan, operational management can be divided into several components such as financial, space and user management and also maintenance and refurbishment as a key component (Quah, 1998).

According to Boussabaine and Kirkham (2004), unplanned and unexpected maintenance and refurbishment costs can amount to half of all money spent on existing buildings. In the United Kingdom, total spending on building maintenance costs increased 66 percent the in about last ten years. This shows that maintenance is an important aspect of the total ownership costs of building. Recent research demonstrate that cost of operation and maintaining a building can be approximately five times the cost of capital over the life of the building (El-Haram and Horner 2003; Boussabaine and Kirkham, 2004). Operation and maintenance phases are usually the longest in the life cycle of constructed assets but these phases are often neglected. The separately identifiable costs associated with operation and maintenance often occurs repeatedly (BS ISO, 2008). As stated by BIFM (2002), about 45 percent of annual turnover in construction industry is spent on maintenance and refurbishment. From the survey done by them, it is indicated that the biggest problems were changing layout, data and communication system and electrical services in term of relative costs.

In most cases, maintenance management of public universities are similar with the other public buildings in Malaysia. Government has strategically allocated for maintenance of university buildings in line with the allocation for the

maintenance of public infrastructure and assets. Every five years Malaysian development plan carries the amount of allocation allocated for maintenance expenditure of university buildings.

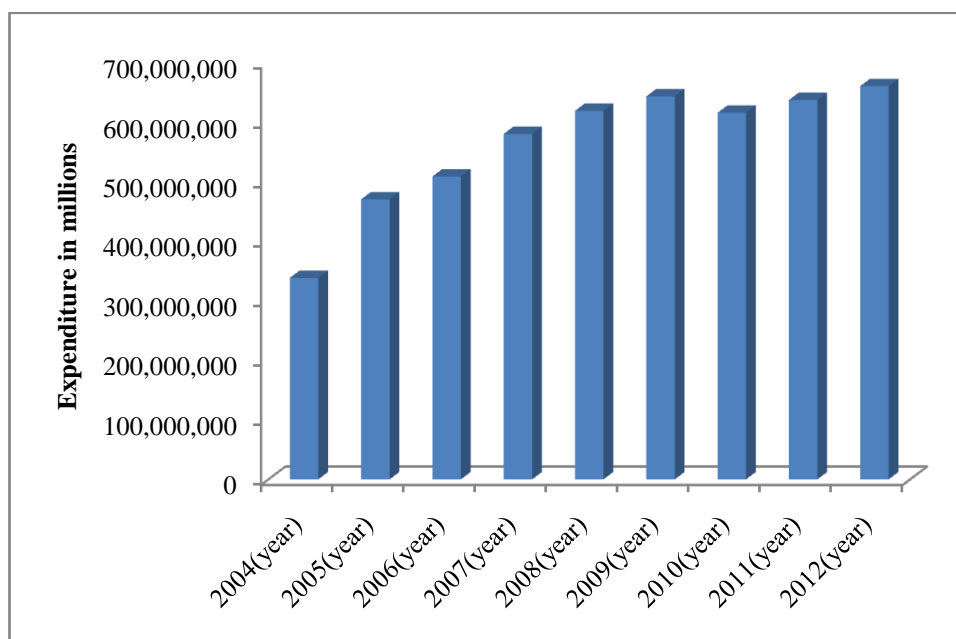


Figure 1.1 Expenditures on maintenance of public university buildings

(Source: Ministry of Higher Education Malaysia, 2012)

University buildings possibly face the same backlogs maintenance wise, like other public buildings and infrastructure even though a detail data on the expenditure of maintenance works or activities in university buildings is not available. Figure 1.1 above outlines the maintenance expenditure on public university buildings from 2004 to 2012, where overall, there are continued increase in the amount of expenditure on public university building maintenance, except in 2010, there was a slight decrease in the expenditure. Increase in the allocations and expenditure does not provide any evidence in improving the maintenance condition or cost involved and according to Olanrewaju et al (2010), increase in the allocation could only open ways to tactical attention rather than value-based consideration. Therefore more and more steps initiated then onwards are to improve the building maintenance procedures and approaches.

Other than that, Public Work Department (PWD) in The Star, 4 September 2009, have stated that, rising in cost, high public demand and obliteration in resources are some of the challenges that have been faced by them and resource

optimization and value for money measures are needed in justifying any consideration for project implementation (Judin Abdul Karim, 2009). Simultaneously, projects can no longer be based solely on the most economical capital costs with little attention to the consequential operational and maintenance costs. These changes allied with key government initiatives, have underpinned the benefits that Life Cycle Costing (LCC) can bring to the industry. Thus, the life cycle cost in the development of project is needed. Buildings, which eventually become assets to the universities, not only have to be well conceived during planning, design and construction but have to also consider all the needs and costs of maintaining and operating them over their life cycle.

Convention held under National Asset and Facilities Management themed “Enhancing Values through Total Asset Management in the 10th Malaysia Plan” sets some objectives to be achieved in facilities management like formulating sustainable integration of asset planning, life-cycle costing, monetization, performance monitoring, good governance and best-practices in managing the Malaysian built-environment under one of the objectives (NAFAM, 2009). It reveals that government urges life-cycle costing to be implemented in managing assets and facilities performance in order to manage the government assets effectively. Review of the Tenth Malaysia Plan (2011-2015) the government decided to focus on life-cycle of the assets and facilities that needs an integrated approach in managing and measuring the performance in order to reduce the cost of maintaining it. The Government is concerned about the life-cycle of the assets and wanted to avoid the infrastructure that was built cheap to become costly to maintain. The benefits of life cycle cost varies for buildings such as lower first cost, favourable environment impact, increased comfort for building occupants in terms of services provided and etc can be achieved. Benefits can be obtained according to the goal and budget of the asset and buildings (Davis et.al, 2005).

Embarking on an integrated planning system is one of the strategic approaches and by implementing it, there are many aspects and best practices in asset and facilities management that can be adopted and one of it, is the whole life-cycle costing (NAFAM, 2009). Incorporating such features and concepts in place could move the nation towards a developed nation in term of infrastructure and also

mentality to adopt the different aspect or culture of asset and facilities modernization. The design and construction of projects require thoughtful review and consideration of how they will best function and endure to provide valuable services over many, many years. As such their service delivery potential can be maximized and that risk and maintenance cost are manageable over their entire life. Therefore, considering total costs over the life cycle of the asset at the early stage, from initial capital, operation and maintenance to disposal, including the cost of delivering services using these assets, will be a great opportunity for cost saving in the long run (Judin Abdul Karim, 2009). Even though many literatures suggested LCC to be applied as early as in the design stage but the availability of data “*Life cycle assessment faces various problems in the process of application and the main of all is the data availability and quality which might degrade the accuracy in the result (Reap et.al, 2008)*” is the impeding factor to make this done.

Recently the paradigm has begun where, starting from the commercial building managers to the government building and project bodies are riveting in maximizing effectiveness and saving money by evaluating their projects in view of the buildings life cycle cost. Besides this, there are relatively few articles written about the frequency of Life-Cycle Costing (LCC) use (Korpi and Ala-Risku, 2008) and it is necessary for more sources in LCC based on case study which could fill the heterogeneous elements in LCC concept. For an example a study in Finland stated that only 5 percent of large industrial companies had used LCC (Hyvonen, 2003) while in Sweden, 66 percent of the companies applied LCC in their buildings on the decision making (Sterner, 2000). According to Ardit and Messiha (1999), in United States, 40 percent of the administrations used LCC in evaluating their building projects. A survey conducted in Germany among real estate professional indicated that LCC in decision making process is considered much higher, nearly 60 per cent than the application of LCC calculation, which is only 5 per cent (Pletzer, 2006). It is also argued that LCC in facilities management and building sector remains limited and has not yet achieved the status of common tool and lack of practical knowledge besides awareness are the main reasons that contribute to this slow development (Sterner, 2000; Pletzer, 2007). There is a substantial gap between LCC application in decision making and LCC calculation where LCC in decision making considered easier in implementation. Likewise, there is no consistency in the LCC

implementation because of the long process it involves results lower limit of its application.

By definition, LCC deals with future costs and the future is uncertain. The uncertain future involves risk, and in the case of operational period, it implies risk in investment and also maintaining process. LCC is performed over an agreed period of analysis and it prudent to make a clear decision whether the analysis involve only part or the life cycle or the entire life cycle of the constructed assets. Though the benefits of life cycle cost vary especially in term of economical interest, several shortcoming of life cycle cost has affected adopting the technique into building maintenance and management reason being the complicatedness of technique, data availability etc, from a managerial view. In this case, adopting comprehensive approach in implementing life cycle cost technique could be a better solution. One of the theoretical bases for LCC is declaration of alternative strategies to be evaluated before implementing LCC (Flanagan et al, 1989).

In practice, LCC has limited acceptance in the decision making process caused by human and technical factors such as lack of motivation to use LCC, contextual factors that restrict its use, methodological problems and limitations and access to reliable data (Cliff and Bourke, 1999). LCC methodology itself has limitations due to the lack of universal method, standard format or useful software (Cliff and Bourke, 1999). Many public institutions restrict LCC adoption result from internal bureaucratic structure (e.g. public capital and revenue budgets) with the management of each making decision and choices in isolation of others.

This research attempts to study the comprehensive life cycle cost of maintenance activities in order to develop a reliable and implementable methodology for service provider in decision making. Identification of maintenance activities involve in the process and relating costs according to the activities (cost causalities) can benefit the effective way of conducting LCC. LCC should consider all of these factors in order to create the most effective choices for the facilities. Apparently, facilities maintenance level is still in general state, in term of LCC application in facility and property or building management that causes managing and maintaining its cost to be difficult. This can be noted from the limited literatures available on

LCC for facilities and on the other side the available literatures are given less priority on facilities matter. But, it is important to consider the total costs which often omitted, in order to make an informed decision (Emblemsvag, 2006). Thus, activity-based LCC which is an improvement over the traditional LCC approaches (Emblemsvag, 2003) can be obtained in order to overcome the shortcomings of traditional LCC as discussed earlier. Since activity-based LCC is “activity based”, it is useful to explain on ABC

Activity-based cost or costing (ABC) is a method of costing activities that are necessary for the production of products or services (Dandago, 2003) and ABC data considered as more accurate and reliable and it is also useful for decision making and performance evaluation (Sarbpriya Ray, 2012). ABC is a suitable tool for service organizations and it has been implemented by healthcare organizations, government organizations etc (Sarbpriya Ray, 2012). The value of ABC lies in its philosophy, management implication, its capability to provide organisational learning and it links to quality, value, economic value added and most importantly it is a process-oriented approach. While, LCC can handle multiple cost objects but many LCC approached cannot handle multiple cost objects well because overhead cost consideration are too simplistic or often omitted altogether, thus, ABC can add much value to LCC (Emblemsvag, 2006).

Hence, this study addresses the gap by incorporating the life cycle cost and activity-based cost frameworks as AB-LCC into a combined cost management model. By combining both of these powerful tools, positive attributes can be harnessed and also used for monitoring and evaluation. According to Emblemsvag (2003), AB-LCC was estimated to combine the strengths from multiple areas into one comprehensive approach for forecasting economic performance whether it is costs and/or profits and its contributions are many. A model that combines LCC and ABC could adapt the strategic ABC process and use them as a means of collecting, organizing and analyzing activity and cost information. This would overcome the above mentioned limitations of LCC by organizing complex activity and cost data, the link between activities and cost measures. Activities that are important and less important can be assessed based on priority and from an organization’s strategic point of view.

Public assets in Malaysia face critical problems in maintenance and that cause the government to spend higher cost every year. Public universities can be said as one of the important public asset that represents the country's image to the world but very seldom that this purpose plays its role. Budget allocation is the most important factor in order to achieve successful maintenance work and the reason for frequent changes in maintenance planning is mainly due to limited allocation of budget (Boyle, 2003). Since, the government plan a transformation which is economy based on knowledge (knowledge-economy) to achieve national prosperity and wealth, through acknowledgement of improving overall effectiveness of the universities, a greater level of autonomy and accountability is needed for public higher education institutions to pursue the knowledge-economy target (World Bank, 2007; Government of Malaysia, 2011; Azlan Shah Ali, 2009). In order to integrate its research universities into the global research community, Malaysia will need to consider several options for restructuring its research funding mechanisms. Basically, funding of public universities does not consider aspects such as individual performance and productivity but; based on performance in terms of quality and employability of the graduates, and efficient use of available resource, Thus, they need more funding especially to improve the quality of physical facilities for the teaching and learning process.

The asset and facilities management department is in-charge to maintain universities in support of the university's mission. Therefore, the focus of facilities operation is to maintenance activities which are both preventive and corrective that ensures a safe and comfortable environment for university students, faculty and also staff. The source of funding for public universities maintenance is through the government allocation of budget and each university planned for their maintenance activities related in educational and general facilities. In the case of research universities, the funding and allocations are similar as it is categorised under same status which is 'Research University'.

Based on reports and manuals gathered from research universities, currently maintenance cost management in public universities are carried out based on percentage estimation, complaints received and also routine expenditure (Universiti Sains Malaysia, 2012; Universiti Putra Malaysia, 2012 and Universiti Malaya, 2012).

It is also stated that allocation is used to be segregated to the departments or units related to facilities maintenance activities based on five to ten percentage, either increase or decrease, but usually it always increases. Normally, five percentages is the reasonable percentage used to predict or estimate the coming year's maintenance expenditures. Even though, some of the universities occupied with systems for the cost management regarding maintenance, it is claimed that the level of utilisation is not satisfying because of reasons such as not user friendly and lack of manpower to handle (Universiti Sains Malaysia, 2012; Universiti Putra Malaysia, 2012; Universiti Kebangsaan Malaysia, 2012 and Universiti Teknologi Malaysia, 2012) . Decision on costs based on LCC is believed to be an effective way for those involve in the top management of these public universities (Research Universities) and it is in the process of proposal and some in the progress of development.

Organizations becomes increasingly aware of costs with a long-range perspective such as environmental costs, infrastructure costs and the costs of major assets lifecycle costs become more and more important to assess, predict and trace (Emblemsvag, 2007). Based on the government's requirement as stated in NAFAM (2009) for an integrated asset planning system with a strategic approach through life cycle costing could provide a best-practice in managing the Malaysian built-environment and the issues in the current application of LCC status such as lack of motivation to use LCC, contextual factors that restrict its use, methodological problems and limitations and access to reliable data (Cliff and Bourke, 1999), LCC based cost management benefits the education institutional organisation to maintain their facilities.

Inadequacies in the LCC implementation as stated above, the activity based cost (ABC) attempted in cost management of maintenance to compliment and produce effective management. ABC can be considered as a method of costing activities that are necessary and important for the production of the products or services for example activities being undertaken (Dandago, 2013). According to Sarbapriya (2012) ABC interprets on ways to see operating costs and provides methods to dissect the underlying activities that cause costs to exist. This allows any organisation to track the cost associated with activities performed for produced products or in delivering services. Lack in comprehensive and simplified method of

LCC in use, activity-based life cycle cost approach considered compromising one another in providing a cost effective maintenance management in public university.

AB-LCC as cost management process has not been attempted in university building maintenance facilities, but AB-LCC has been studied in product manufacturing, system maintenance and construction project as activity-based life cycle cost (Emblemsvag, 2003; Kayrbekova, 2011 and Ren and Zhang, 2007). Fundamental aspect of LCC which look into the breakdown of costs of assets or buildings in total and general can be changed by looking into detail breakdown of costs based on each activity occurs for the facilities. On the other hand, as stated by Drury (2001), facility level involve in ABC considered to have less published implication and practice compared to other levels such as unit level, batch level and product level. Hence, the conspicuous disparity between LCC and ABC can be resolved through AB-LCC, in addition the activity-based life cycle cost process can be adopted in achieving government policies and maximize the budget allocation in an effective way.

1.3 Research Questions

1. What is the current method of estimating future maintenance cost in Malaysian Research University?
2. What are the challenges(s) being faced in implementing LCC in Malaysian Research University facilities maintenance?
3. What are the maintenance activities that the research universities consider as critical in the development of activity based LCC?
4. How far can maintenance activities be incorporated into Activity-based LCC?

1.4 Purpose of the Research

LCC analysis of maintenance function in facilities management is based on a key concept of economics used to evaluate alternatives for equipment and projects and this theory is a well-defined and extensively applied in business and investment analysis. LCC analysis basically is required to demonstrate that maintenance savings are sufficient to justify the investment cost (Barringer, 2003). Public universities

focus maintenance as an important supporting service in running its functional purpose meanwhile contributing to the social needs of the facilities users. While, activity-based cost (ABC) integration into the life cycle cost concept will be researched and implementation on the case study explored through this research objectives. The aim of this research is to develop a cost-effective process of activity-based LCC for public university facilities maintenance.

There are four objectives to be achieved in this research. These are as listed below:

1. To identify the current method of estimating maintenance cost in Research University.
2. To evaluate the implementation of LCC in Malaysian Research University facilities maintenance.
3. To determine the facilities maintenance activities involve in providing services in research university building.
4. To develop activity-based life cycle cost for research university facilities maintenance.

The first objective starts with identifying the current method of estimating maintenance cost in public university in order to have a clear understanding on the current applications, procedure and techniques in terms of costs and allocations; and to identify the gaps, while the second objective is to look into the real situation in Malaysian public universities implementing LCC in term of awareness and challenges. The third objective of this research is to identify the activities that are critical in maintaining building facilities. Maintenance processes and the costs elements involve during maintenance period throughout an asset's life span with the optimization of the economic attractiveness in terms of cost-effectiveness identified. Maintenance process will be branched mainly into maintenance of building facilities services and focused on public universities buildings. The fourth objective is to relate or integrate maintenance activities into LCC to form an activity-based LCC and finally, to develop simple-to-use and reliable process model of maintenance activity-based LCC for research university. These critical elements of activities will assist the public universities facilities maintenance related department in foreseeing the long-

term financial elements involve in sustaining the academic buildings' services. This marks the major difference of the proposed model from the other existing LCC models that exists today in facilities management field.

1.5 Significance of Research

The important role of building facilities as a business resources acknowledged growing internationally and this led for more attention towards facilities management as a business practice and as a profession that can contribute to the business success (Then and Tan, 2006). From the initial design and planning, facility management encompasses a broad scope of services crucial to the health, safety and welfare of all its inhabitants. These services include cost-conscious, flexible solutions to maximize budgets, extend services and increase security for manufacturing plants, medical and commercial, utilities, retail centres, educational facilities, museums and parks. Facilities management can be defined as the coordination between demand and supply of facility services to support the effectiveness of an organization (Kok et-al, 2011).

With facilities budgets in most organization tighter than ever, facilities management field faces growing pressure to maximize its value and quality, and public university is not an option. Initial cost remains a practical consideration, but the amount of money spent over the entire expected life of asset is also an important part of the long-term exposure (Schwartz, 2008). This deficiency simultaneously, put an urge to excavate a proper cost management and analysis on the maintenance of building facilities. The key aspect of facilities and its management is longevity of asset lifespan providing better return on investment through reduced life cycle costs (Emirates Business, 2009). These costs include building maintenance, repairs, utilities, gates and barriers, sound and music systems, furnishing and artwork investments, landscaping, roadways and parking facilities, administrative costs, custodial services, garbage collection, recycling, roadways, parking garages etc. Maintaining a building on a long-term basis extends the usefulness of buildings and by undertaking LCC technique in facilities maintenance could result in maintenance costs to be properly managed and controlled.

Even though, LCC have been described and established widely for all types of facilities all over the nation, there is still a lack of thorough literature on LCC application by-case in different types of building, for example in public institutions. Especially in Malaysia, it can be said that LCC application are very limited in use in facilities management sector. Furthermore, forecasting of future cost a certain level may seem as an inexact science particularly in building, evaluation of the real LCC is a difficult task because it involves various uncertainties throughout the long investment period. However, this should not discourage the industrialist and managers to apply LCC in whole life period of building (Arja et-al, 2009; Kirkham et-al, 2001; Woodward, 1997). Further suggested by Arja et-al (2009), that LCC analysis should be developed and extended in application for different types of building to obtain more reliable results and different LCC formulae to contribute to other functions of building service (e.g. building design and costing); and in decision making and planning process (e.g. maintenance management).

Knowing the life cycle cost of facilities services in public universities could contribute through various ways for example in outsourcing of functions and ownership, in planning maintenance management procedures and etc. Relevantly, it has to be confessed that building life cycle costing analysis is difficult for the organizations especially public based organization to comprehend when available building funds are tight, but the rewards in effective facilities management are potentially great (Picus, 2000). Thus, it is important to carry out this study to provide significant contribution to the facilities management field and related industry in handling the financial matter and decision making in order to achieve cost-effectiveness and sustainability in management. In order to achieve this, activity-based life cycle cost (AB-LCC) has been attempted and a process model development for the implementation of AB-LCC studied in research university. However, this study is not attempt to explore further on the cost-effective part as AB-LCC is studied as an effective approach in resolving the issues highlighted in this study.

LCC application in public university seems to be more complicated because of financial allocation, building structure and its age, top management concern and etc. The impact of cost management is not only important in manufacturing industry

that focuses on profit but also public organisations like public institutions where they require a concrete base of cost information as a support in management. By considering criticalness in LCC application and to manage cost effectively, activity-based life cycle cost is suggested as a best approach in public universities building facilities maintenance.

The notion of the present study is to address cost-effective aspect of public universities maintenance of facilities provided to the students, faculty members, administration staffs and others. Since the public universities consumes various types of building according to its functions, i.e. academic, residential, cafeteria, administrations and etc, this study has chosen academic building to focus on, as the impact upon the academic buildings as an institutional building towards achieving students productivity is much higher compared to other types of buildings in public universities.

The literature review started with the focus on LCC and ABC models and concepts and the appropriate way of cooperating maintenance activities which reviewed in term of activity based and required elements of data for LCC in institutional buildings. This information will contribute to create a clear process model of activity-based LCC for maintenance. The field of life cycle cost is wide and to be able to keep focus on the facilities maintenance, frequently words have been combined with building and facilities. Consequently, data collection is on LCC implementation in research universities and also maintenance cost activities (ABC elements) involve in research university spending on facilities maintenance in term of civil, mechanical, electrical, cleaning and other related facilities offered based on specifications and ordinances provided by public universities in maintaining their buildings which results in the activity-based life cycle cost process model.

1.6 Scope of Research

This research is limited in scope to the public higher educational institutions (public university) in Malaysia and focused mainly on those public universities entitled under research university status. Public universities are under the control of

government with objectives in line with Ministry of Higher Education. There are 3 categories of public higher educational institution in Malaysia which are research universities, comprehensive (broad based) universities and focused (specialised) universities. To date, there are 20 public universities, out of which five of it is research universities, four comprehensive universities and 11 focused universities. Research universities have been selected to be studied-on in this research based on the funding level or stage. Malaysian government provides fund about 90% for the public universities whereas the remaining 10% is covered from students' fees. Reason for focusing on research universities is mainly because of restrictions and new policies that have been introduced by government in the funding criteria for these universities. Research universities mentioned are Universiti Malaya, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia, Universiti Sains Malaysia and Universiti Teknologi Malaysia. Furthermore, the existence of these universities have been for more than 20 years compared to other universities and that is considered as an important criteria of life cycle cost where life cycle cost involve long term period cost.

These universities are not only categorised under the same title but also are among the oldest public universities in the country with most of them having been operating for more than 30 years. Thus, the maintenance of building in those universities would have passed through several critical stages since it had been established; simultaneously it could best represent the taxonomy of building service maintenance in higher educational institution. Hence, five public universities will be included in the survey which represents about 25% of the total public universities in Malaysia.

1.7 Methodology

There are many different aspects of life-cycle cost analysis, and it is very easy to be overwhelmed and deviate from the strategic direction while undertaking life-cycle cost analysis (Fabrycky and Blanchard, 1991). In this research, relevant existing LCC models reviewed and activity-based facilities maintenance cost combined in producing a process model. Facilities maintenance cost elements,

available facilities maintenance cost estimating methods, LCC implementation level and understanding, cost-effective maintenance through maintenance activities in public university are the information type that will be gathered in achieving the research objective.

The methods undertaken in this research are literature review, interview survey, questionnaire survey and also case study as a major approach in defining the maintenance costs elements of activities in facilities management. The case study involves the asset and facilities maintenance department of public universities which are authorised to construct buildings, operates and maintains them thereafter.

Universities management are trying to evaluate long-term costs more now than in the past. The trend to go this route is taking over the design and construction industry for the higher-education market. Further discussed by Wiens (2005) that architects and construction personnel serving the higher-education marketplace report that first cost are often the defining issue, even though officials know that going in the life-cycle cost route may be more financially advantageous in the long run. In order to examine this misconception, life-cycle cost adaption in public university facilities maintenance will serve one of the needs in the process of cost-effective maintenance cost management.

The following section discusses on the particular methods that carried out in order to achieve the objectives outlined in this research. Interview survey conducted to identify the currently available maintenance cost estimation or analysis or even evaluation methods, to evaluate the implementation of LCC public universities' maintenance of facilities. Through this step, the current challenges, applications and the connection between cost-effectiveness and maintenance activities cost in public university is identified. While, questionnaire survey undertaken in identifying the critical maintenance activity cost element in term of the level of importance given by the service providers of public university and develop a process model of activity-based LCC in facilities maintenance. The final result validated through another interview with experts on the applicability and acceptance level of the process model (Refer to Figure 1.2).

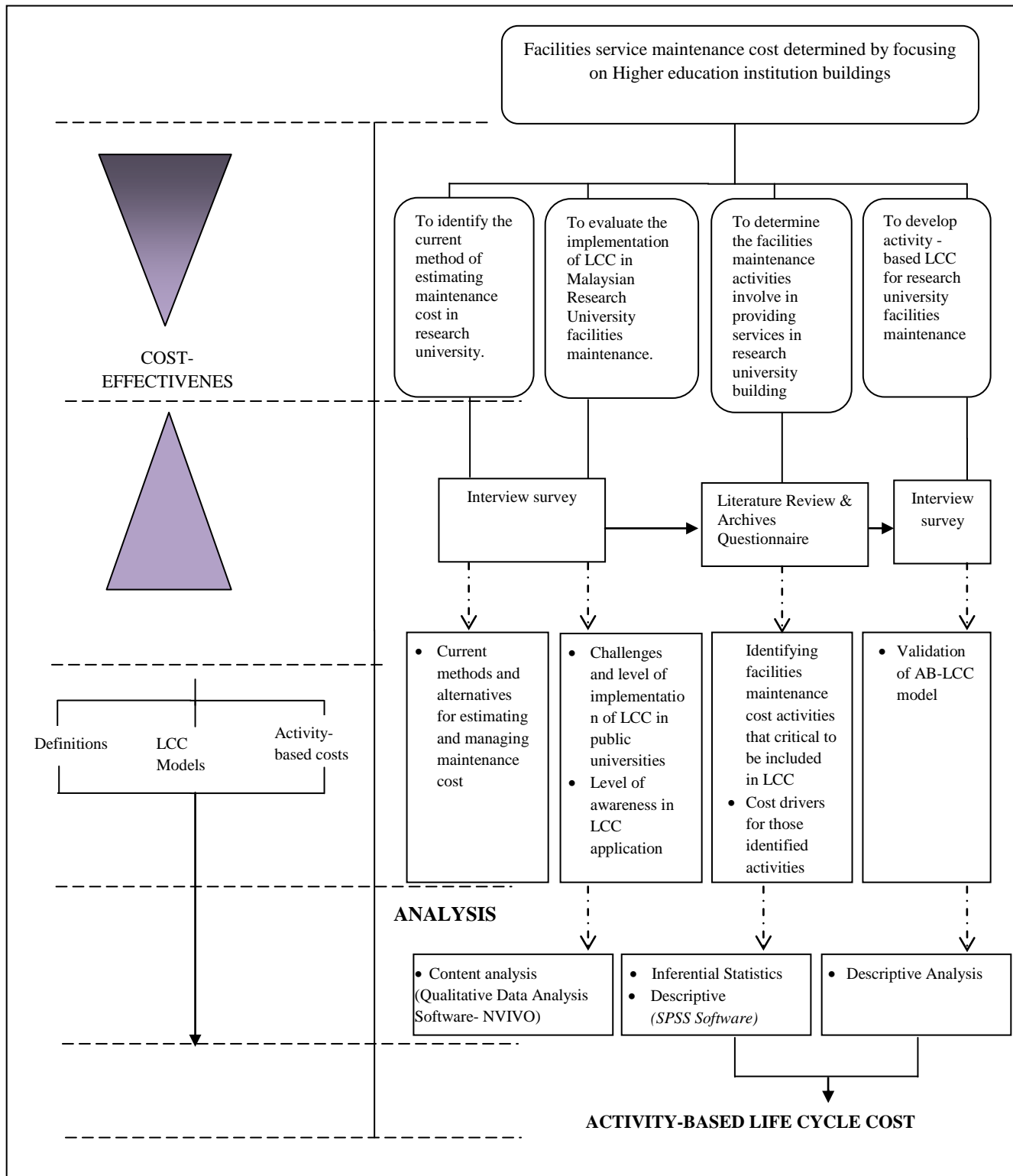


Figure 1.2 Research framework

1.8 Organization of the Chapters

This research arranged into eight chapters. Chapter one provides the introduction into the subject matter, problem statement, significance and purpose of the research undertaken as part of this thesis.

Chapter 2: Discusses the background, development, and various models of life-cycle cost analysis, and its application in maintenance management. Activity based costs also reviewed thoroughly to signify the involvement of activity-based LCC. This Chapter is part of the literature review.

Chapter 3: Highlights the basic of building life cycle and path to maintenance process. Life cycle cost of operational process and maintenance, starting from the acquisition phase through the occupancy explored and explained. Cost effectiveness element discussed in relation to the facilities maintenance. Activity-based LCC process identified and explained. This Chapter is also part of the literature review.

Chapter 4: Explains the methodology developed and applied in further analysis of the development process of activity-based LCC for facilities maintenance in public university.

Chapter 5: Analysis and discussion of the qualitative results explains the current scenario in LCC implementation in maintenance of facilities.

Chapter 6: Analysed and discussed the quantitative results by identifying the important elements to be considered in term of facilities maintenance activities as a cost-effectiveness approach.

Chapter 7: Explains the validation process of the activity-based life cycle cost process model for facilities maintenance and the results obtained through validating the process model developed in this research.

Chapter 8: Finally, conclusions of this research are presented in Chapter eight.

1.9 Summary

Activity-based life cycle cost management derived in a process model for this study by achieving the research questions and objectives developed with the methodology outlined in this chapter. The critical elements and/or activities from the model will become critical success factors for those involve in successfully implementing facilities maintenance. An activity-based LCC model of cost-effectiveness will prove useful towards determining what cost elements constitute the major influence institutional building facilities maintenance and also cost management in maintenance process which covers a big scope of facilities management of a building, at the same time, to know how these elements affect service provider to make a financial decision for a public university building. This research will contribute towards better understanding the role of each cost element that is likely to occur in operation and maintenance period of the public university building life-cycle. Next chapter discusses first stage of the literature review on LCC and ABC method followed by AB-LCC concept development.

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