ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

LCC Application for Estimating Total Maintenance Crews and Optimal Age of BTS Components

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Abstract*-- PT. XYZ is a company engaged in telecommunications services which customers spread throughout Indonesia. In order to meet consumer needs, companies must always keep the reliability of telecommunication devices such as tool is the Base Transceiver Station (BTS). BTS has a very important role in the process of telecommunication, so if the Base stations damage, it would result in down time that will affect the company. Based on historical data, corrective maintenance for BTS tool in 2013 reached 16% of the overall total corrective maintenance telecommunications equipment. This happens because there are frequent sudden damages to the appliance. Maintenance managers have not been able to calculate the cost of maintenance needs to ensure performance tool because it could not predict the condition of these tools. Additionally, the tool will undergo aging and increased hazard rate, so that the calculation of the economic life of the unit and the optimal amount of maintenance crews need to be done.To determine the economic life of the unit and the optimal amount of maintenance crews in this study used the method Life Cycle Cost(LCC) and to simplify the calculation, then made an application LCC calculation.The output of this application is to estimate useful life of components and estimate the optimal amount of maintenance crews.

***Keyword*--Economic age, Life Cycle Cost, Maintenance Cost, optimal maintenance crews.**

I. INTRODUCTION

Today, telecom products are a necessity that could not be avoided. Besides being used as a tool for communication and entertainment, telecom products are also used as a tool to help businesses. Although telecom products classified as secondary needs, but the needs of the telecommunication products continues to increase each year. This is evidenced by the continued development of various types of telecommunication products.

PT. XYZ is a company engaged in telecommunications services, to meet customer satisfaction, the company should pay attention to the reliability of the equipment that is always ready and able to meet customer needs, especially the reliability of the Base Transceiver Station (BTS).Based on information source from Indonesian Cellular Telecommunications Association (ATSI); estimates that as many as 15 thousand BTS units will be built this year.Investment value estimated for the construction of up 60 percent compared to 2011. From the existing of BTS, nearly 50% of them had an average age of over 10 years, 30% between 5-10 years and the remaining less than 5 years [1].As is generally a device, if it has been so long used in order to keep good performance with an adequate level of reliability is certainly in dire need of treatment programs, as well as the BTS. In a telecommunications network architecture, BTS holds a very important role. If there is interference on the causes BTS, BTS would be down, it will result in a loss of potential revenue and lead to a loss of consumer confidence of the company. Hence the need for an effective treatment method and efficient base stations so that availability can be maintained with a good base stations due to the availability of a telecommunications network is a very important part because the effect on network coverage, customer satisfaction and customer network performance. Availability is the probability that the system will operate satisfactorily, fulfilling its function, and timely if it is used in certain circumstances.

The longer used, the tool will undergo aging and increasing of hazard rate will occur. This will cause high tool maintenance costs and high lost of revenue. Therefore, the optimal tools age analysis are aimed to enable companies to determine retirement appliance should be done so that the tools are not forced to operate after the optimal age.

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Company has implemented a tool maintenance activities carried out by the maintenance crews. The company has a maintenance crew that took care of the maintenance activity. The number of maintenance crews is essential in the maintenance activities because if there is a broken tool simultaneously, the device must be fixed so that the tool can be operated quickly. If the number of maintenance crews are not met, these tools will have a long downtime that can reduce corporate profits. However, if the company has too many maintenance crews also will increase the cost in the form of overhead costs and the cost of investment in doing maintenance. Therefore, an analysis of the amount of the maintenance crews need to be done to obtain the number of optimal maintenance crew.

The method of analysis used to estimate the economic life of components and determine the optimal amount of maintenance crews is using LCC method.To make more simple and speed up calculation of complicated LCC analysis then LCC application using Java language was made, the input of application are general cost, purchasing cost, operation cost, maintenance cost and shortage cost. While the output of this application are the estimated economic life of the tool and the optimal amount of maintenance crews. To make application output user friendly and easier to read the results of the analysis, so there are three option that user can choose this aretable, chart and pop up final resultsdialog.

II. LITERATURE REVIEW

A. Maintenance Management

Maintenance is defined as the activity that component or system defective will be returned / repaired under certain conditions at a certain period [2]. Maintenance classified as follow:

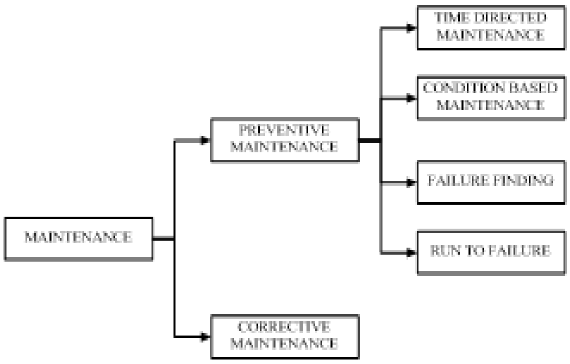

Fig 1. Classification of Maintenance activity [2]

B. Failure Rate Pattern

The basic pattern of decay rate function λ will change over time as a tool / machine operation. The curve rate of damage or called Bath tube-Curve is a curve showing the rate of decay pattern that is common to a device [3]. The rate of damage will follow a basic pattern as follows:

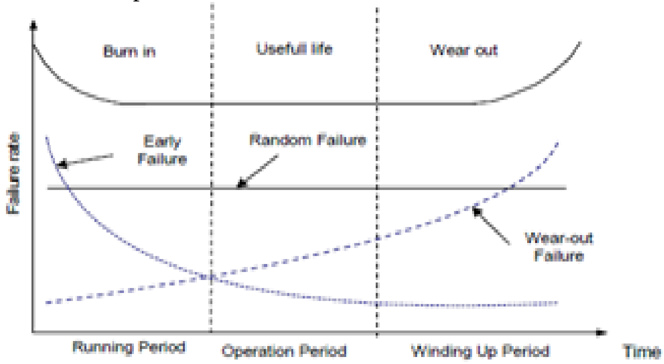

Fig 2. Bathtub Curve [3]

From Figure 2 is known pattern of damage can be divided into three phases, namely:

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1) Phase Burn - In Period, at time T0 - T1*: D*escribe the damage rate decreased with the addition of component operating time has Weibull probability density function with a value of $\beta < 1$

2) Phase Useful Life Period, at time T1 - T2:This phase illustrates the damage rate is constantover time with the addition of the component operations and have exponential probability density function with a value of $\beta = 1$.

3) Phase Wear - Out Period, at the time T2 - T∞:This phase depicts the rate of damage increases with the addition of components operating time. This phase has a probability density function of the Normal and Weibull with a value of $\beta > 1$.

C. Life Cycle Cost

According to Blanchard and Fabrycky [4], Life Cycle Cost (LCC) is the sum of the estimated cost from the beginning to the end, the total expenditures experienced during operated, it could be either equipment or the project. The purpose of the LCC analysis is to choose the most cost effective approach of a series of alternatives that term cost of ownership (ownership) the shortest achieved [5].In this study, the problem is modeled through LCC approach, which is illustrated as follows:

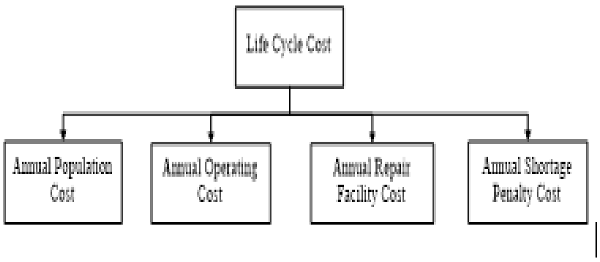

Fig 3. Life Cycle Cost Model

Life cycle cost contains:

- Annual population cost
- Annual operating cost
- Annual repair facility cost
- Annual shortage penalty cost

The formulation of LCC analysis is:

$AELCC = PC + OC + RC + SC$ ………………………………………………………………..………(1)

AELCC : annual equivalent life cycle cost
PC : annual equivalent populationcost
OC : annual operating cost
RC : annual repair facility cost
SC : annual shortage penalty cost

1) Population Cost

(A|P,i,n) : Equal Payment Series Capital Recovery.
(A│F,i,n) : Equal Payment Series Singking Fund
N : Number of Units
B : Book Value

Book Value

$B = P - n (P-F)/L$ ………………………………………………………………………..…………..…… (2)

B: book value
P: First cost of a unit
n: Retirement age of units $n > 1$
F: Estimated salvage value of a unit
L: Estimated life of the unit

$F = P - (i \times P)$ ……………………..…………………………………………………….……..… (3)

P: First cost of a unit
i :Inflation

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2) Annual Purchasing Cost

Annual purchasing cost = P(A|P,i,n)*N ………………………………………………………………………….. (4)
(A|P,i,n) : Equal Payment Series Capital Recovery
N : Number of Units

3) Annual Population Cost

Annual population cost = annual purchasing cost + annual equivalent population cost

4) Operation Cost

Operating costs are the costs of each period of the operation of a device. In the calculations defined by the equation
OC=EC+(TK*Salary)*12 …………………………………………………………………………….….…… (5)
OC = Operating Cost
TK = Number of Workers
Salary = Employee salary costs per month
Employee salary multiplied by 12 months for the cost per year.

5) Maintenance Cost

Maintenance costs are costs incurred as the cost of maintenance on the unit itself continuously in each period during the unit operates [6]. In its calculations, maintenance costs are influenced by a large number of maintenance crew provided and the cost of repairs per unit, defined as follows:
MC = Cr + (CL x M)+Cc+Ce ………………………………………………………………………….... (6)
MC : Maintenance Cost
Cr : Repair/replace cost
CL : Labor Repair Cost
Cc : Consumable Cost
Ce : Equipment Cost
M : Maintenance Crew

6) Shortage Cost: Shortage cost is a cost to be incurred due to the lack of the device as a result of a shortage of channels to fix defective devices.
SC = Cs [E(S)] ………………………………………………………………………………………. (7)
SC : Shortage Cost
Cs : Shortage Cost per unit
E(S) : Expected number of units short
E(S) = ∑_(n=0)^NnPn …………………………………………………………….……….……….......(8)
N :Number of Units
n :The number of defective units.
Pn:Probability damaged machine

Pn: P0 x Cn ………………..…………………………………………………………………...………..... (9)
Cn = (N!(λ/μ)^n)/((N-n)!M!M^(n-M)) ………………………………………………...……………….. (10)
P0: Probability none damaged machine
N :Number of units
n: Number of defective units
M: Maintenance Crew
λ: MTTR (Mean Time To Repair)
μ: MTBF (Mean Time Between Failures)

III. DATA AND RESEARCH METHODOLOGY

A.Data

This research was conducted in the area of West Java, region operations 3 during one year.The data required for this study was obtained through :
1) Literature study:
The method of data collection by studying the theory and knowledge that will serve as thebasis for

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ISO 9001:2008 Certified
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completing the research problem.The theoryused in this study is the concept ofcaremanagement,statistical concepts, and Life Cycle.

2) Field studies: the method data collection bysurveying the field to acquire supporting data andinformation used to resolve the problem.

3) Data collection techniques: for interview andobservation. The data required in this study include:

Time to failure data, time to repair data, existing maintenance cost, price data tools, the existing amount of maintenance crew, energy cost and labor operating cost data, shortage cost data, data on the number of tools.

B. Research Methodology

The initial view of the LCC application consists of two parts: first to enter all the data required for the calculation of LCC and the second is the facility to see the results of the application of three output options that can be selected in the form of tables, graphs and the final result. The general researchmethodology of this paper can be seen in the figure 4 below.

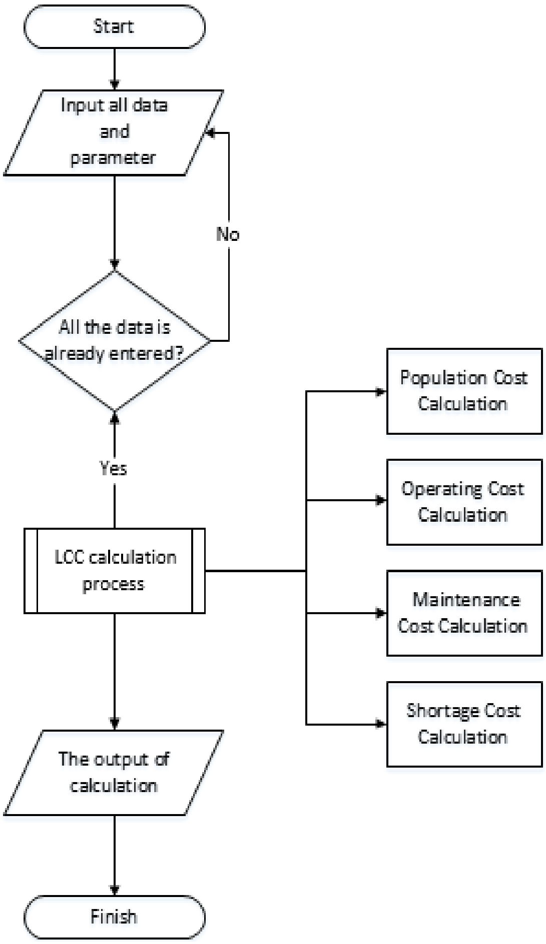

Fig 4. General research methodology

C. LCC Application

Due to the number of Base Transceiver Station (BTS) that operate are numerous,it will require a software application to simplify and accelerate the LCC calculation. The input of this application are:General Cost: Machine Name, Number of Machines, Time Interval Analysis, Maintenance Crew, inflation, salary employees.Population Cost: Purchasing Cost, Interest Rate.Operation Cost: Energy Cost, Total Workforce, Maintenance Cost: Repair Cost, Consumable Cost,Equipment Cost, Shortage Cost, MTTR and MTBF.

For data input MTBF and MTTR are stored in an excel file as shown in figure 5 and figure 6.Figure 7 show the display to input the necessary data for the LCC application.

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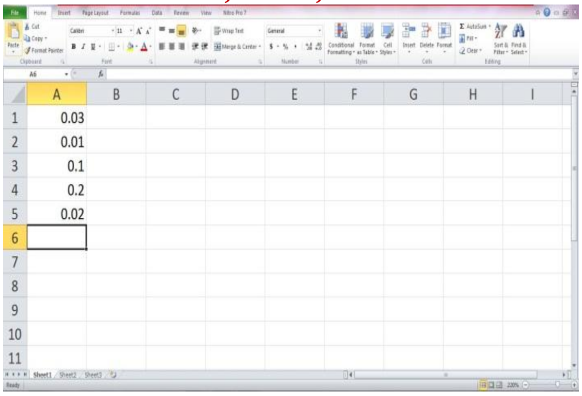

Fig 5. MTTR File

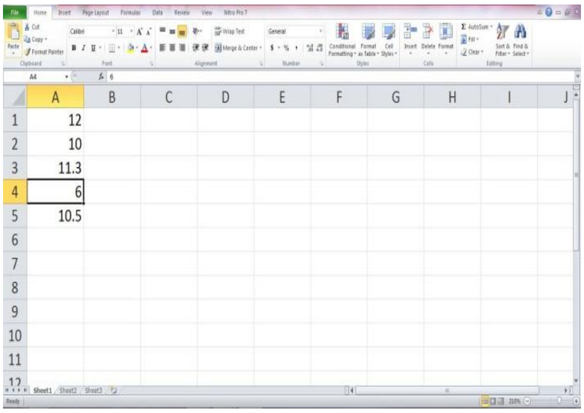

Fig 6. MTBF file

Fig 7.The display input of LCC parameter

IV. RESULTS AND DISCUSSION

Total Life cycle cost is the calculation of the total cost of the entire system, from initial purchase until the end of the life of the system. LCC total population obtained from the sum of cost, operating cost, repair facility cost and shortage cost. LCC calculation results for a device using the application are as follows:

1) Output: There are 3 ways output of this calculation that is by:

a) Table:

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Table Annual Life Cycle Cost

M	1 Year	2 Year	3 Year	4 Year	5 Year
1	188032171	171371163	168960292	170738818	172658084
2	212031574	196091068	194412592	196708088	199669910
3	236031380	220811037	219871386	222875525	226681996
4	260031284	245531021	245331632	249075863	253694145
5	284031227	270251012	270792435	275287339	280706319
6	308031189	294971006	296253510	301503897	307718506
7	332031162	319691001	321714738	327723193	334730700
8	356031141	344410998	347176061	353944131	361742898
9	380031126	369130995	372637446	380166132	388755099
10	404031113	393850993	398098875	406388860	415767302
11	428031103	418570992	423560335	432612107	442779507
12	452031094	443290990	449021819	458835737	469791713

Fig 8. The Total of LCC Equipments

b) Graphic:

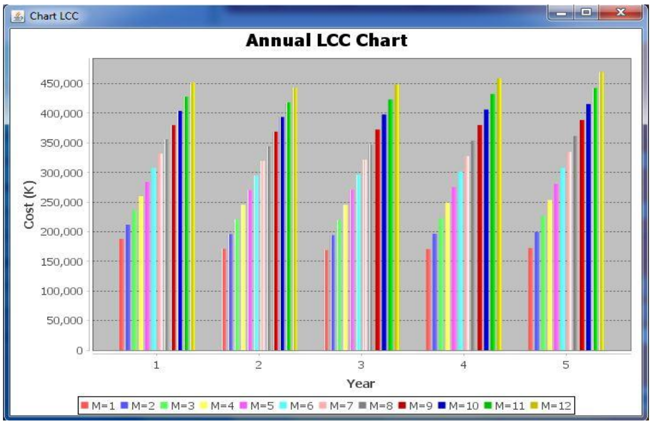

Fig 9. The results of the calculations in the chart

From the output in a table or graph, we can see the annual life cycle cost of the parameters that have been entered previously.

c) Pop up dialog final results:

Output from the application of information LCC smallest value of the annual life cycle cost calculation following the cost given the amount of information, the age of the appliance and economical, the number of necessary maintenance crew.

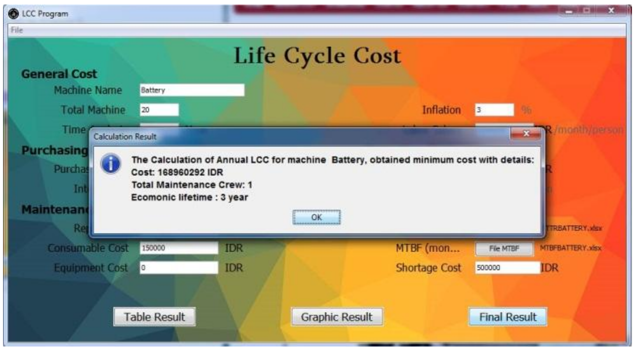

Fig 10. Results of calculations in PopUp

At each step in the calculation of the Population Cost, Operating Cost, Maintenance Cost, Shortage Cost and Annual Life Cycle Cost saved in pdf with the same path file on the application. For Cost Population files stored with the name "Population Cost.pdf" Operation Cost saved file with the name "Operation Cost," Cost Maintenance files saved with the name "Maintenance Cost.pdf" Shortage Cost saved file with the name "Short ridge Cost.pdf", and the Annual Life Cycle Cost calculation fileis saved with the name "Annual LCC.pdf".

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Determination of the optimal amount of maintenance crew selected from the total cost of which has the smallest total cost. From the total LCC calculation, then that has the smallest total cost is the amount of maintenance crew M = 1 person per shift, with economical age means of n = 3 years with a total cost of Rp 168,960,292.If the tool is operated with short lifespan, the annual purchasing will be expensive, but with aannual population equivalent cost will cheaper. Unlike the total LCC with a longer retirement age who tend to the significant increase in operating costs, facility repair cost, and annual shortage cost.

V. CONCLUSION

This paper is proposed the Life Cycle Cost (LCC) application to simplify the calculation of economic life of the unit and estimate the optimal amount of the maintenance crew for Base Transceiver Station (BTS) maintenance activity. With this LCCapplication, it can help LCCcalculations faster and more practical. There are two options results of this application, in the form of tables or graphs of total annual cost.From the tables and graphs, it can be seen that the optimal amount of maintenance crews, optimal age of the component and optimum total cost.The resultshow that the optimum amount of maintenance crew is 1 person per shift, with economical age 3 years ans total cost of Rp 168,960,292.

For future work, another thing that needs to be studied in-depth is the change in the total LCC as changes in the amount of the maintenance crew. Seen on the LCC calculation results on the entire retirement age that tends to increase the total LCC linearly with increasing maintenance crew. It is influenced by increasing costs due to increased repair facility maintenance crew. This increase is more dominant than the shortage cost reduction. So the overall total LCC increases linearly with increasing number of the maintenance crew.

REFERENCES

[1] "2013 Annual Report" of PT. Telekomunikasi Seluler, PT Indosat Tbk, PT XL Axiata Tbk.

[2] Ebeling, Charles. 1997, "An Introduction to Reliability and Maintanability Engineering" Singapore : The McGraw-Hill Companies Inc.

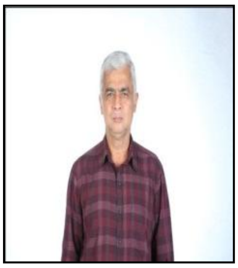
[3] Corder. A, "Maintenance Management Technique", Erlangga, 1996, Jakarta.

[4] Blanchard, Fabrycky, 1990. "System Engineering and Analysis ", 2nd ed. Englewood Cliffs: Prentice-Hall.

[5] Barringer, H. Paul and David P. Weber. 1996. "Life Cycle Cost Tutorial". Texas: Marriott Houston Westside.

[6] Jardine, A.K.S dan Campbell, D.John,s " Maintenance Excellence " Marcel Dekker. 2010

AUTHOR BIOGRAPHY



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1. Prediction Model for Speedy Customer's Category at Pt. Telekomunikasi Indonesia, Tbk.
2. Optimization of Preventive Maintenance Program and Total Site Crew for Base Transceiver Station (BTS) Using Reliability Centered Maintenance (RCM) and Life Cycle Cost (LCC) Method.
3. Predicting And Clustering Customer to Improve Customer Loyalty and Company ProfitPreventive Maintenance Program Using Reliability Centered Maintenance Method and Procurement Of Spare Part Based On Reliability (Study Case : PT . XYZ),

ISSN: 2319-5967
ISO 9001:2008 Certified
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Volume 4, Issue 2, March 2015

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2. The Optimization of Maintenance Time and Total Site Crew for Base Transceiver Station (BTS) Maintenance Using Reliability Centered Maintenance (RCM) and Life Cycle Cost (LCC)

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2. Riding Pattern Analysis of Taxi Passengers (Case Study of Korean Taxi Company),
3. Preventive Maintenance Schedule for Base Transceiver Station (BTS) using Reliability Centered Maintenance (RCM) method.