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

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ABSTRACT

In telecommunications business, the performance of BTS become very important role. The BTS performance should be in good condition and ready to operate anytime. In the event that causes disruption of BTS and BTS fail to operate and break down, this situation will effect to loss of potential revenue and lead to loss of consumer loyalty to the company. Hence is needed an effective treatment for maintaining BTS so that availability and performance of BTS can be maintained properly.

The method used in the treatment of BTS in this study to determine treatment priorities of existing equipment in the BTS based on vital functions and data destruction in order to obtain its value MTTF and MTTR,is the RCM method (Reliability Centered Maintenance) and to determine the optimal number of sites crew for treatment BTS. is used LCC method (Life Cycle Cost)

By using the RCM method, the results of the determination of the critical components based on damage data, are obtained seven set of equipment as critical components. They are BKCM, battery, generator, converter, arrester, sensor and AC and obtained each value of MTTF and MTTR. While the number of site crew required in the BTS treatment based on the results of calculation and data processing with the LCC method, obtained the most optimal amount based on the cost is 4 site crews.

Keywords: *BTS maintenance, Cost, Site Crew*

1. INTRODUCTION

Indonesian Cellular Telecommunications Association (ATSI) noted, until the end of 2011, the number of mobile subscribers reached 250 million subscribers. In fact, Indonesia's population is expected to "new" to reach 240 million subscribers. That is, if the calculated percentage, Indonesia has a mobile penetration of 110 percent. Growth in the number of customers is certainly also be balanced with infrastructure development order to cover and provide excellent service, no blank spots and no over-load. It means that the operator will almost certainly increase the number of BTS (Base Transceiver Station) to increase the performance of its services. Until the end of 2011, growth in infrastructure, seen from the total Base Transceiver Station (BTS), reaching 97,000 BTS.

The fact of base stations, nearly 50% of them have an average age above 10 years, 30% of them between 5-10 years old and the rest are less than 5 years (source: APIMTEL). As is generally a device, if it has been used for so long in order to keep good performance with a sufficient level of reliability is certainly in dire need of maintenance programs, as well as the BTS.

The type of care and current maintenance intervals are determined based on the needs estimates only without going through an assessment and calculation details first. It is potential and very possible to make not precisely the type of activity and the maintenance time interval. More away, if this is allowed to be potentially at harm because operator BTS drop, experienced down time, loss of revenue, and the ballooning cost of maintenance. In addition treatment program is also frequently done by appointing a vendor at a cost that is only based on estimates of work as well. Budget calculation and determination of its real cost of care is almost never done. This is potentially ballooning maintenance costs of the actual real budget.

In addition, corrective maintenance activities which often can lead to delays in the BTS operation. Therefore, it needed to takes action appropriate preventive maintenance to prevent damage which may result in delays in the BTS operations.

Preventive maintenance is done by the method of RCM. RCM is a process used to determine the appropriate treatment for a component or system in an operational context [1]. The purpose of RCM is to restore the function of a system as before. Another thing which is also important in the maintenance management team is the amount of maintenance (site crew). In normal condition, if the number of sites with the same crew that no amount of damage, then any damage will be handled without the need for repair queue, but it is often the case if the number of base stations which suffered damage greater than the number of sites that need repair crew. This will cause damage repair queue and the impact will cause the loss of revenue due to additional unnecessary down time. But, on the other hand, increasing the number of site crew will bring greater cost because of the additional over head costs for team work and additional investment costs for the repair. Conversely, the lack of tools and site crew will also cause the cost to be high as a result of a long down time to the detriment of the company due to disrupted communication and consumers are not satisfied with the services are provided by the company.

2. THEORETICAL BACKGROUND

2.1 Maintenance Management

Maintenance is an activity that is carried out to ensure that the component or system can be used in accordance with its function [1].
The main goal of maintenance is to extend the useful life of the asset, ensure optimum availability of installed equipment for production/services and investment profit as much as possible, ensure the operational readiness of all equipment necessary in emergency activities and ensure the safety of any person using the facility.

2.2 Reliability Centered Mintenance (RCM)

Reliability Centered Maintenance(RCM) is a process used to determine the appropriate treatment for a component/system in an operational context [2]. The main objective of the RCM are as follows:

1. To establish the priority associated with a design that can support preventive maintenance.
2. In order to obtain useful information for improving the design of components that proved unsatisfactory reliability.
3. To develop activities related to preventive maintenance can re store back the reliability and security at the level of the actual equipment when the equipment or system is in decline.
4. To achieve the above objectives at minimum total cost.

2.3 Risk Priority Number (RPN)

Risk Priority Number (RPN) is a simple multiplication of severity, occurrence and detection and the magnitude of the multiplication result indicates the priority of corrective action.
1. Severity is associated with severity ratings or the effect caused by a failure caused by machine.
2. Occurrence is the rate of occurrence of an engine damage or failure.
3. Detection is the estimate of the numerical assessment of the likelihood of detecting failure modes arising from certain causes.

2.4 Life Cycle Cost

Life Cycle Cost is the sum, the estimated cost of from start to the settlement, better equipment and project as specified by the study analysis and estimate of total experience for life [3]. The purpose of analysis LCC is to choose the approach of the most effective from a series of alternatives so that cost term ownership (of) the short time-frame.
In this research, the model on the LCC, that are use are illustrated as follows:

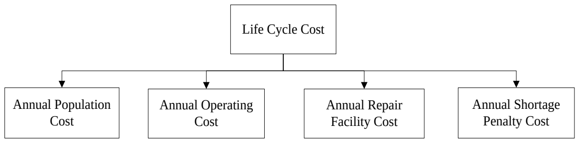

Fig. 1 LCC Model

Formulation of LCC are:
AELCC = PC + OC + RC + SC

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

3. RESEARCH METHODOLOGY

The conceptual model of the research as shown in Figure 2.

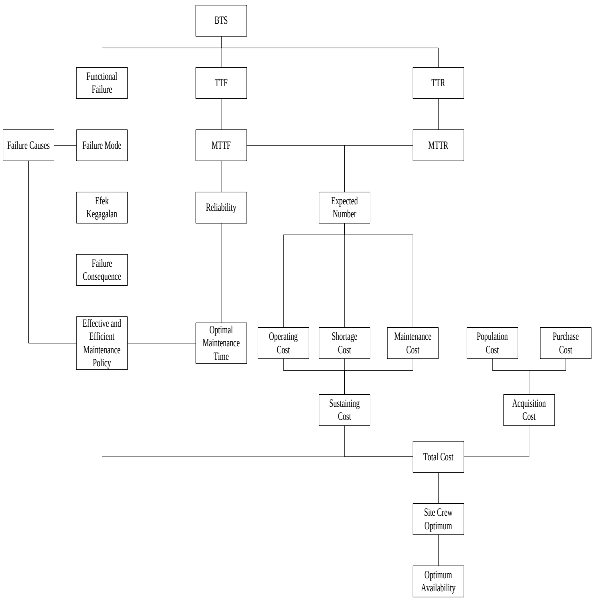

Fig. 2 Conceptual Model

4.1.1.1

The selected system is a system that has the greatest frequency of failure or it's functionality. Through the system, will be determined the limits and description of system. In operation, the system must have experienced failure. This failure can be identified failure modes and causes of failure so can be known the effect of the failure against entire system. To avoid a large amount of system failure, effective and efficient maintenance policy with optimal treatment interval is needed so that the system can have a high reliability.

Therefore, it is necessary to determine an effective treatment policy to detect and prevent failures, and can reduce the consequences of failure. Through RCM policy, it can be determined effective preventive maintenance policy by managing maintenance interval as effectively as possible based on the reliability parameters. Determination of the reliability parameter depends on the distribution of time between the damage. Having chosen an effective maintenance policy, then a review of the amount of Life Cycle Cost (LCC) carried out. In the calculation of the cost by using the LCC, there are two important cost factors and should be taken into account, acquisition cost and sustaining cost. Then after doing the LCC, then it could be known that the optimal cost and also can be determined how many site crews are provided to repair the damage the base stations, so that optimal availability can be achieved.

4. RESULT AND DISCUSSION

4.1 Critical Components

Based on historical data damaged population of BTS, indicate that BCKM modules, batere, generator, converter, arrester, sensor and AC were chosen because provide the largest total downtime. Furthermore, all the equipments referred to as a critical component. Ordering was conducted by using a Pareto diagram method. Pareto (1896) states that in a series of elements to be controlled, a small fraction of all elements always gives a great effect.

4.1.1 Value Calculation of Mean Time to Failure (MTTF)

4.1.1.1. MTTF of BCKM Module

From the data obtained, the distribution that formed is weibull. The equation to calculate MTTF is :

$MTTF=(\theta).\Gamma(1+1/\beta)$………………(1)

where,
β = Shape Parameter
θ = Scale Parameter
$\Gamma(x)$ = Gamma Function
The parameters used are:

β= 0.3243038
θ= =1584.35
$MTTF=1584.35.\Gamma(1+1/0.3243038)$
$MTTF=1584.35.\,\Gamma(4.08)\rightarrow$ obtained from the Gamma function table
MTTF= 1584.35 x 2 = 3168,7 hours
Thus, the average TTF value BCKM module is 3168,7 hours.

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4.1.1.2 MTTF of Battery Module

From the data obtained, the distribution that formed is weibull. The equation to calculate MTTF is :

MTTF=(θ).Γ(1+1/β)………………(1)

The parameters used are:

β= 0.30211

θ= =1470.35

MTTF=1470.35.Γ(1+1/0.30211)

MTTF=1470.35. Γ(4.31)→ obtained from the Gamma function table

MTTF= 1470.35.x 2=2940.7

Thus, the average TTF value Battery module is 2940.7 hours.

4.1.1.3 MTTF of Generator

From the data obtained, the distribution that formed is exponential. The equation to calculate MTTF is :

MTTF=1/λ …………………………….(2)

where,

λ = damage rate

The parameters used are:

λ=0.0000998

MTTF=1/λ

MTTF=1/(0.0000998)=10020.04008

Thus, the average TTF value of generator is 10020.04008 hours.

4.1.1.4. MTTF of Converter

From the data obtained, the distribution that formed is exponensial. The equation to calculate MTTF is :

MTTF=1/λ

λ=0.0000588

MTTF=1/λ

MTTF=1/(0.0000588)=17006.80272

Thus, the average TTF value of converter is 17006.80272 hours.

4.1.1.5. MTTF of Arester Modul

From the data obtained, the distribution that formed is exponensial. The equation to calculate MTTF is :

MTTF=1/λ

λ=0.0000611

MTTF=1/λ

MTTF=1/(0.0000611)=16366.61211

Thus, the average TTF value of generator is 16366.61211 hours.

4.1.1.6. MTTF of Sensor Module

From the data obtained, the distribution that formed is weibull. The equation to calculate :

MTTF=(θ).Γ(1+1/β)………………(1)

β= 0.53216

θ= 1773.21

MTTF=1773.21.Γ(1+1/0.53216)

MTTF=1773.21. Γ(2.87)→ obtained from the Gamma function table

MTTF= 1773.21 x 1.79=3182, 91 hours

Thus, the average TTF value sensor is 3182,91 hours.

4.1.1.7. MTTF of Air Condition (AC)

From the data obtained, the distribution that formed is weibull. The equation to calculate MTTF is :

MTTF=(θ).Γ(1+1/β)………………(1)

β= 0.613461

θ= 1692.31

MTTF=1692.31.Γ(1+1/0.53216)

MTTF=1692.31. Γ(2.63)→ obtained from the Gamma function table

MTTF= 1692.31 x 1.46

MTTF= 2470.77 hours

Thus, the average TTF value Air Conditioner is 2470.77 hours.

4.1.2 Value Calculation of Mean Time to Repair (MTTR)

4.1.2.1. MTTR of BCKM Module

From the data obtained, the distribution that formed is weibull, the parameters used are:

β=0.8987722

θ=7.8903425

MTTR=7.8903425.Γ(1+1/0.8987722)

MTTR=7.8903425.Γ(2.1126)

MTTR= 8.2975

Thus, average TTR value of BCKM Module is 8.2975 hours.

4.1.2.2. MTTR of Battery

From the data obtained, the distribution that formed is normal. The equation to calculate MTTR is:

$MTTR = \mu$…………………………(3)

Where,

μ = damage mean

The parameters used are:

σ= 1.0056734

μ=4.5008912

MTTR= 4.5008912

Thus, Average TTR value of Generator is 4.5 hours.

4.1.2.3. MTTR of Generator

From the data obtained, the distribution that formed is normal. The equation to calculate MTTR is:
σ= 0.903543
μ=7.84453
MTTR= 7.84453
Thus, Average TTR value of Generator is 7.8 hours.

4.1.2.4. MTTR of Converter

From the data obtained, the distribution that formed is weibull, the parameters used are:
$\beta = 0.6657810$
$\theta = 6.324570$

$$MTTR = 6.324570.\Gamma\left(1 + \frac{1}{0.6657810}\right)$$

$$MTTR = 8.324570.\Gamma(2.5019)$$

$MTTR =$ 8.324570 x 1.32934 =11.06 hours
Thus, average TTR value of Converter Module is 11.06 hours.

4.1.2.5. MTTR of Arester

From the data obtained, the distribution that formed is weibull, the parameters used are:
β= 0.8893341
θ= 6.8543021
MTTR=6.8543021.Γ(1+1/0.8893341)
MTTR=2.8543021.Γ(2.1244)
MTTR=3.01 hours
Thus, average TTR value of Arester Module is 3.01 hours.

4.1.2.6. MTTR of Sensor

From the data obtained, the distribution that formed is normal. The equation to calculate MTTR is:
MTTR= μ…………………………(3)
The parameters used are:
σ= 2.4578903
μ= 2, 34687
MTTR= 2.34687
Thus, Average TTR value of Sensor is 2.34687 hours.

4.1.2.7. MTTR of AC

From the data obtained, the distribution that formed is weibull, the parameters used are:
β= 0.5678908
θ= 7.666780
MTTR=7.666780.Γ(1+1/0.5678908)
MTTR=1.666780.Γ(2.76090)
MTTR= 2.5 hours
Thus, average TTR value of AC Module is 2.5.hours

4.1.3 Total Life Cycle Cost

Calculation of the total cost of the whole system is done starting from the initial purchase to the end of the system life. The equation to calculate LCC is:
LCC = AcC + St C ………………….(4)

where,
LCC : *Life Cycle Cost*
AcC : *Acquisition Cost*
StC : *Sustaining Cost*

By knowing the total overall cost, it will show the total cost to be incurred for any number of site crews proposed. Total LCC obtained from the sum of sustaining cost and acquisition cost. The result can be seen in Table 1 below.

Table 1. Total LCC

n	m-1	m-2	m-3	m-4	m-5	m-6
1	$ 1,315,584.53	$ 1,022,896.06	$ 965,411.59	$ 961,929.12	$ 971,668.65	$ 984,904.18
2	$ 1,342,122.53	$ 1,027,637.06	$ 963,824.59	$ 957,304.12	$ 966,100.65	$ 979,041.18
3	$ 1,371,938.53	$ 1,033,104.06	$ 963,154.59	$ 953,251.12	$ 960,947.65	$ 973,534.18
4	$ 1,405,419.53	$ 1,039,234.06	$ 963,421.59	$ 949,795.12	$ 956,212.65	$ 968,379.18
5	$ 1,443,041.53	$ 1,046,007.06	$ 964,667.59	$ 947,003.12	$ 951,943.65	$ 963,613.18
6	$ 1,485,335.53	$ 1,053,398.06	$ 966,908.59	$ 944,923.12	$ 948,169.65	$ 959,252.18
7	$ 1,532,899.53	$ 1,061,395.06	$ 970,142.59	$ 943,605.12	$ 944,923.65	$ 955,318.18
8	$ 1,586,402.53	$ 1,069,980.06	$ 974,334.59	$ 943,079.12	$ 942,220.65	$ 951,813.18
9	$ 1,646,634.53	$ 1,079,169.06	$ 979,454.59	$ 943,395.12	$ 940,100.65	$ 948,761.18
10	$ 1,714,510.53	$ 1,088,995.06	$ 985,459.59	$ 944,595.12	$ 938,602.65	$ 946,186.18
11	$ 1,791,081.53	$ 1,099,503.06	$ 992,297.59	$ 946,717.12	$ 937,768.65	$ 944,117.18
12	$ 1,877,566.53	$ 1,110,753.06	$ 999,911.59	$ 949,793.12	$ 937,642.65	$ 942,583.18
13	$ 1,975,368.53	$ 1,122,805.06	$ 1,008,219.59	$ 953,823.12	$ 938,249.65	$ 941,594.18
14	$ 2,086,136.53	$ 1,135,749.06	$ 1,017,162.59	$ 958,817.12	$ 939,631.65	$ 941,185.18
15	$ 2,211,825.53	$ 1,149,715.06	$ 1,026,705.59	$ 964,788.12	$ 941,850.65	$ 941,409.18

From Table 1, it can be determined that the optimal number of repair channels selected from the smallest total cost. From LCC calculation, then that has the smallest total cost is m = 5 repair channel, with n = 12 years in the amount of $ 937,642.65. However, the determination of iterations of retirement age should also consider the initial design life time of the device as well as the development of technology when LCC calculation is done.

In The telecommunications field, generally every device is expected to be replaced every 5 years on average due to technological developments cannot be predicted or foreseen. So in this case the telecommunications xyz company can choose retirement age policy is not only based on the calculation of LCC but still consider the technological development of a device is analysed.

5. CONCLUSION

In telecommunication network architecture, BTS holds a very important role. In the event that causes disruption of BTS and BTS to be down, it will result in loss of potential revenue and lead to loss of consumer loyalty in the company. Hence the need for an effective method of treatment BTS and BTS efficient so that availability can be maintained properly, that is Reliability Centered Maintenance (RCM) method.

By using the RCM method, the results of the determination of the critical components based on damage data, are obtained seven set of equipments as critical components. They are BCKM, battery, generator, conventer, arrester, sensor and AC Calculation and data processing of field data acquisition and secondary data the previous year. Tthe value of the MTTF and MTTR can be seen in table 2.

While the number of site crew required in the BTS treatment based on the results of calculation and data processing with the LCC method, obtained the most optimal amount based on the cost is 4 site crews.

Table 2. Value of MTTF and MTTR

NO	EQUIP MENT	DISTRIBU TION	MTTF (hours)	MTTR (hours)
1	BCKM	Weibull	3168,7	7.89
2	Batere	Weibull	2940.7	
		Normal		4.500
3	Generator	Exponent	10020.04008	
		Normal		7.8445
4	Converter	Exponent	17006.80272	
		Weibull		11.06
5	Arester	Exponent	16366.61211	3.01
6	Sensor	Weibull	3182.91195	
		Normal		2.346789
7	AC	Weibull	2470.7726	2.5

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