DESIGN OF LIFE CYCLE COST (LCC) ANALYSIS CSHARP BASED SOFTWARE TO INCREASE THE EFFECTIVENESS AND EFFICIENCY IN MACHINE MAINTENANCE

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Abstract

Globalisation era is era where technology becomes primary need for every sector in industry. Technology that usually used by manufacturer are robot, machine, information system/ technology, etc. Those technology can help the company to minimize defect and control the poduction time which is one of quality control system scope. One of quality control aspect is maintenance management which often become an issue in a company because it spend a lot of money. Thus, in this era most of company are challenged to find a method that make maintenance more efficient and effective, minimize cost and complexity. The method that suitable with this case is life cycle cost analysis. Unfortunately, most of company lack of industrial engineer in their maintenance department that cause life cycle cost can not be applied in those company, whereas life cycle cost analysis is method that can help the company to get the optimum lifespan of machine or equipment, and how many maintenance crew that needed in every maintenance activity for each machine which drive to the minimum overall cost that has to be paid during the lifespan of machine or equipment. The aim of this research is to build an application or software that can help the company and maintenance department to perform life cycle cost analysis. With this application, it is expected that many companies can push down their expenses and make the machine perform better.

Keywords: life cylce cost, LCC, csharp, C#, application, software, maintenance.

1. Introduction

Globalization era is era where competition among countries, industries, and companies are all open. Period development which more and more faster, drive the society to make the same pace with technology development. Nowadays, technology become very important thing in every sector of industry. Role of technology become primer needs or evenmore is like culture for every entity.

In manufacturing industry, technology which can be applied are robot, machine, or information system or technology. Those kind of technology can help the company to minimize and to control the production time and defect product. This is very related with quality control system, where there are some aspect, and one of the aspects is maintenance management.

Maintenance usually become an issue in the company, because maintenance likely spend a lot of money and sometimes the schedule of maintenance activity collide with production schedule. So that in this era where maintenance develop as fast as the time passed by and it become challenge for company, also method or tool is needed in order to do maintenance which more effective and efficien, so it can push down the cost and complexity.

Based on the explanation, maintenance very identical with cost and lifespan of the machine, this is appropriate with one of the method in maintenance management which is Life Cycle Cost. In order to facilitate the employee or the worker while doing the calculation of life cycle cost analysis, also minimise the time and cost, the calculation of life cycle cost analysis can be done with the help of information technology/ system.

Based on those things, so in this research or final project will be made a software that can perform life cycle cost analysis. The software will be made in C# language. This language choosen as the needs of the code and software itself. On the day forward, this software or application can become an ultimate solution for the company which still lack of industrial engineer in their maintenance department just than have to recruit or lease a cosultant.

2. Method

2.1 Life Cycle Cost

Life Cycle Cost is a calculation of estimation cost from the beginning until the completion of equipment or project as defined by analysis and estimation of total expense along the lifespan study or simply end to end cost that has to be paid so that equipment can operate as its function.

In this reearch, life cycle cost analysis used to define the optimum lifespan, amount of maintennace crew that provided to repair the failure of the machine or object. According to Barringer (1996), LCC has a model, where the model is a representation from a problem that can represent the real problem. In this research, the problem turn in to model through LCC approachment, which illustrate as follows:

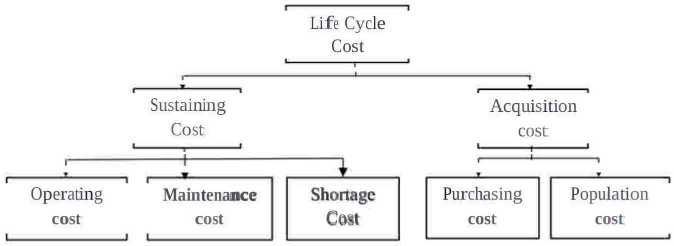

Figure 2.1 Life Cycle Cost Model

Sustaining Cost

Sustaining cost is cost that has to be paid because of ownership toward an equipment or machine during a certain period.

Operating Cost

Operating cost is cost that has to be paid because of operation of an equipment or machine in every period.

Maintenance Cost

Maintenance cost is cost that has to be paid because of maintenance activity toward that equipment or machine continously in every period during the operation cycle of the equipment.

Shortage Cost

Shortage cost is cost that has to be paid because of shortage of unit as a result of shortage of maintenance site crew to repair the equipment which broken.

Acquisition Cost

Acquisition cost is cost that has to be paid because initial purchasing of an equipment or system.

Purchasing Cost

Purchasing cost is overall cost that paid for purchasing an equipment or machine that needed in a system. For every different retirement age, it has different annual purchasing cost.

Population Cost

Population cost is cost that has to be paid in every period of ownership toward the equipment.

2.2 Distribution of Time to Repair and Failure

Distribution Identification have to know what kind of distribution that belongs to failure time and repair time of a machine or component as a purpose. The following distributions are statistics distribution that usually used as failure and repair distribution. [1]

1. Normal distribution or known as bell distribution because the curve looks like a bell. Normal distribution has two parameters which are μ and σ.
   Followed by value of MTTF and MTTR = μ
2. Exponential distribution tend to represent the constant failure rate and independent toward time. Exponential distribution only has one parameter which is μ or λ.
   Followed by value of MTTF and MTTR = $\frac{1}{\lambda}$ = μ
3. Weibull distribution has three parameters which are α, β, dan γ. β represent the lifespan stage of a machine or equipment. If $\beta < 1$ it means machine still in its early stage (phase 1) or new, if $\beta = 1$ it

means machine in its usefull stage (phase 2), or else $\beta > 1$ it means machine in its wear-out stage (phase 3) or old.

Followed by value of MTTF and MTTR = $\alpha\Gamma\,(1 + \frac{1}{\beta})$

2.3 Queue Theory

Queue system is association of customer, channel, an set of rule that settle customer arrival and processing of queue service problem where indicated by five components which are customer arrival pattern, service pattern, unit channel, system capacity to take the customer, and rule about how the customer served.
Queuing type that usually used in maintenance activity are single channel single phase, and multi channel single phase.

3. Designing System

Application or software that will be made is application to calculate life cycle cost analysis. There are some diagrams that made to represent both the business process and also how the system work.

3.1 Use Case Diagram

Use case used to know what the function/ process that include in an application and who have the right to use those functions/ processes.

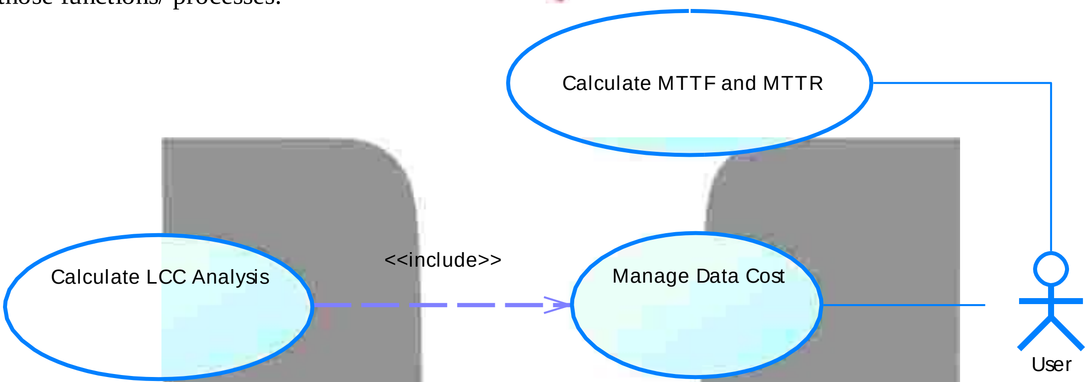

Figure 3.1 Use Case Diagram

Based on Figure. 1 it shows that there are three use cases which are calculate MTTF and MTTR, manage cost data, and then system has to do life cycle cost analysis calculation. It also known that one and only external entity which can operating the system is user, in this final project user refers to maintenance crew.

3.2 Activity Diagram

Activity Diagram is used to shows the flow of process if it looked from two perspective, user perspective and system as well.

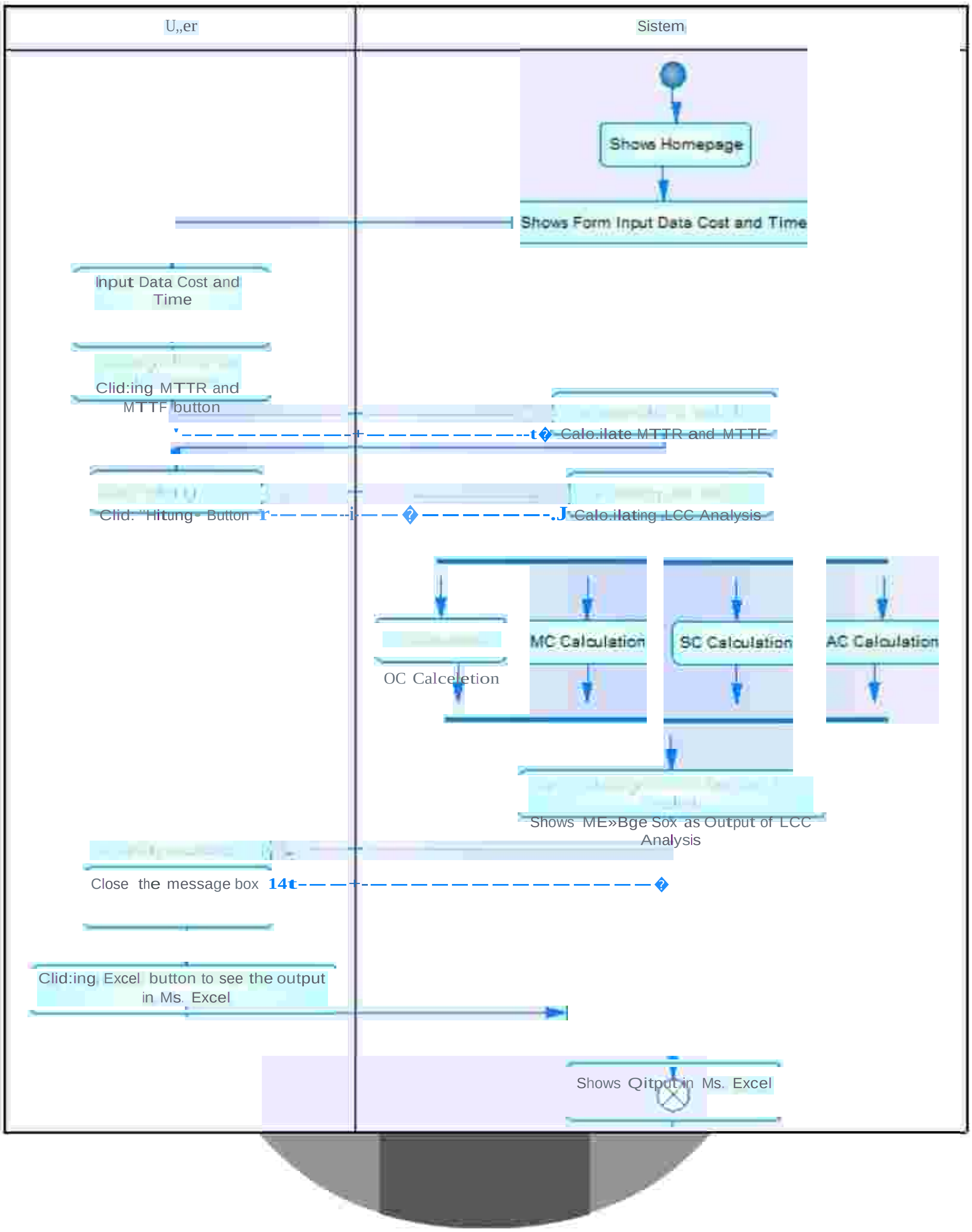

Figure 3.2 Activity Diagram

3.3 Data Flow Diagram

Data Flow Diagram (DFD) is diagram that used to illustrate the flow of the data, what the data that needed for each processes are, where the data and the result store is. Data Flow Diagram of this application/ software is in appendix.

4. Software Making and Testing

4.1 Input/Output Analysis

Table 4.1 Input Data

Input	tipe data	Proses	output	proses	Output
Nama Mesin Interval Waktu Analisis jml Mesin jml TK Gaji TK Inflasi jml Shift Energy Cost	varchar integer integer integer integer double integer integer	Perhitungan Operating Cost OC = ec+((lc*12)*tk)	Hasil Operating Cost OC (Rupiah, Tabel)	Proses Perhitungan LCC LCC = OC + MC + SC + AC	Laporan LCC (Grafik, Tabel, Analisis)
jml TK Inflasi Gaji MC Interval Waktu Analisis Equipment Cost Consumable Cost jml Maint. Crew jml Shift Biaya Perbaikan	integer double double integer double double integer integer double	Perhitungan Maintenance Cost MC = Cr+((lc*12)*tk)+Cc+Ce	Hasil Maintenance Cost MC (Rupiah, Tabel)		
Potential Revenue MTTF/MTBF Parameter 1 Parameter 2 MTTR Parameter 1 Parameter 2 jml TK Inflasi Interval Waktu Analisis jml Mesin	double combobox2 double double combobox1 double double integer double integer integer	Perhitungan Shortage Cost SC = Cs*E(s)	Hasil Shortage Cost SC (Rupiah, Tabel)		
Inflasi Suku Bunga Interval Waktu Analisis Harga Beli	double double integer double	Perhitungan Acquisition Cost AC = Annual Equivalent Population Cost + Total Annual Purchasing Cost	Hasil Acquisition Cost AC (Rupiah, Tabel)		

4.2 Calculation Processes

Population Cost or Annual Equivalent Population Cost

��= � � .... (1)

��= ����� − ���� .... (2)

PC : Annual Equivalent Population Cost
Ci : Annual Equivalent Cost per unit
���n : Equal Payment Series Capital Recovery
���n : Equal Payment Series Singking Fund
N : amount of unit machine
B : Book Value
P : Purchasing Cost

Book Value

�= �− n P −F / � .... (3)

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

Salvage Value
F = P – (i x P) .... (4)
P : first cost of a unit
i : inflation

Annual Purchasing Cost
Annual Purchasing Cost = [illegible]([illegible])*N .... (5)
P : Purchasing Cost
[illegible] n : Equal Payment Series Capital Recovery
N : amount of unit machine

Annual Population Cost or Acquisition Cost
Annual population cost = annual purchasing cost + annual equivalent population cost

Operating Cost
[illegible] = [illegible] + ([illegible] x [illegible] x [illegible] x [illegible] x 12).. (6)
OC : Operating Cost
TK : amount of operator
N : amount of unit machine
Sh : amount of shift per day
Gaji : operator monthly salary
Multiplied by 12 moth for annual cost

Maintenance Cost
[illegible] = [illegible] + [illegible] + [illegible] + ([illegible] x [illegible] x [illegible] x 12).. (7)
MC : Maintenance Cost
Cr : Repair/replace cost
Cc : Consumable Cost
Ce : Equipment Cost
M : Maintenance Crew
Sh : amunt of shift per day
GM : maintenance crew monthly salary
Multiplied by 12 moth for annual cost

Shortage Cost
SC = Cs [E(S)] .... (8)
SC : Shortage Cost
Cs : Shortage Cost per unit
E(S) : expected number of units short

[illegible] = $\sum_{[illegible]=0}^{[illegible]} n \; x$ [illegible] .... (9)

N : amount of unit machine
n : amount of unit machine which broken
Pn : Probability of machine broken

Pn = P0 x Cn.. (10)

[illegible] = [illegible]! ([illegible] / [illegible])^[illegible] / ([illegible])! [illegible] ^{M} .... (11)

P0 : Probability 0 machine broken
N : amount of unit machine
n : amount of unit machine broken
M : Maintenance Crew
λ : MTTR (Mean Time to Repair)
µ : MTBF (Mean Time between Failures)

Single Channel Single Phase Queuing System

$$Pw = \frac{\lambda}{\mu} \quad (12)$$

$$P0 = 1 - \frac{\lambda}{\mu} \quad (13)$$

Multi Channel Single Phase Queuing System

$$P_0 = \frac{1}{\sum_{n=0}^{r-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{1}{r!}\left(\frac{\lambda}{\mu}\right)^r \frac{1}{1-\rho}} \quad (14)$$

$$P_w = 1 - P_0 \quad (15)$$

Where, $\rho = \frac{\lambda}{r\mu}$ (16)

r = amount of channel or maintenance crew

4.3 Application Form

Homepage

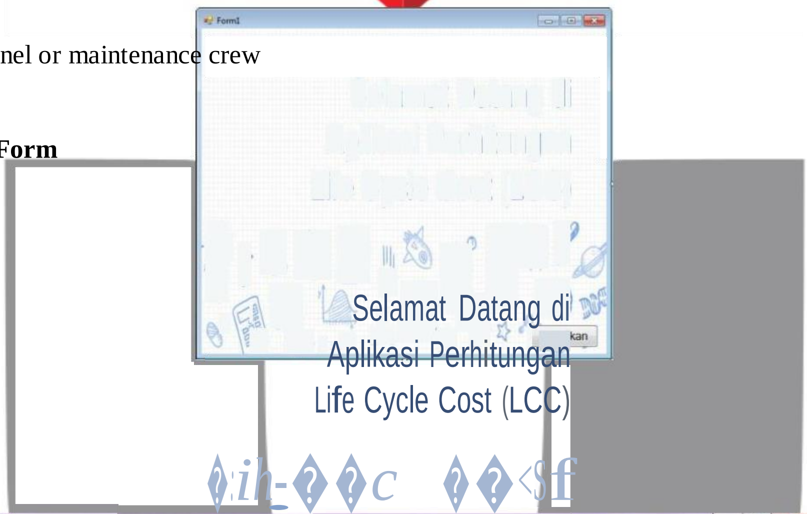

Figure 4.1 Homepage of the application

Form Input

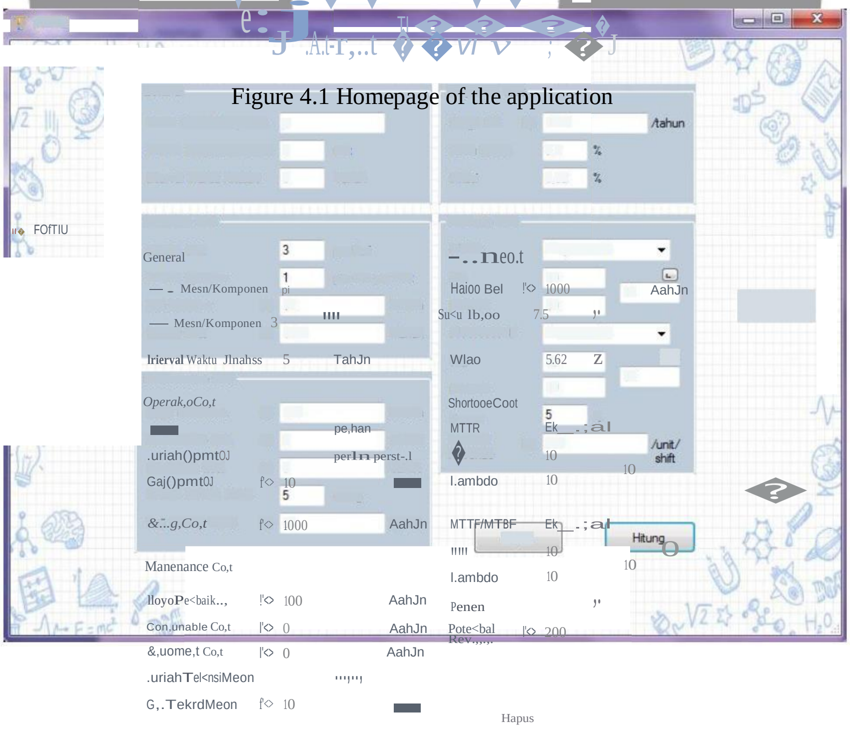

Figure 4.2 Input Form of the application

Form Output

	M=1	M=2	M=3	M=4	M=S	M=6
Tahun1	Rp 17350.n&.426	Rp 17.432.713.719	Rp 17.524.930.792	Rp 17.619.6523n	Rp 17.715.369.438	Rp 17.B11.582.625
Tahun2	Rp 10.133.186.521	Rp 10216.IIJ1.449	Rp 10.312.305.326	Rp 10.411.767214	Rp 10.512.515339	Rp 10.613.904.104
Tahun3	Rp 7.B13.342.659	Rp 7.896.166.076	Rp *1.9962n.1.2S*	Rp 8.100.575.388	Rp 8206.535.730	Rp 8313.323.573
Tahun4	Rp 6.719.97&.848	Rp 6..801.315.018	Rp 6.905.085.284	Rp 7.014.271.485	Rp 7.125.605.767	Rp 7238.009.038
Tahun5	Rp 6.120.173.922	Rp 6..198.101.027	Rp 6.305.158.002	Rp 6.419.222.004	Rp 6536.062.683	Rp 6.654.284.487
Tahun6	Rp 5.no.97&.233	Rp 5.842.908.840	Rp 5.952.688.171	Rp 6.071.535.633	Rp 6.193.973.004	Rp 6318.195.029
Tahun7	Rp 5569.729.732	Rp 5.632.201.067	Rp 5.743.B84.833	Rp 5.867.307.790	Rp 5..995.373.054	Rp 6.125.744.761
Tahun8	Rp 5.466.732.189	Rp 5.515.130.002	Rp 5.627566.100	Rp 5.755.204.610	Rp 5.B88.847.688	Rp 6.025.472.066
Tahun9	Rp 5.436.267.286	Rp 5.464.461.715	Rp 5.576.058.946	Rp 5.707.350.727	Rp 5.B46.411.249	Rp 5.989.326.120
Tahun10	Rp 5.465.145.308	Rp 5.465.009.790	Rp 5.573.600.185	Rp 5.707.715.603	Rp 5.BS1.885.029	Rp 6.001.038.563
Tahun11	Rp 5547.681312	Rp 5.508.455.732	Rp 5.611.115.359	Rp 5.746..871.951	Rp 5.B95.644.157	Rp 6.050.862.863
Tahun12	Rp 5.683.408.753	Rp 5.590.854.528	Rp 5.683.668.806	Rp 5.819.420.188	Rp 5.972.027.045	Rp 6.132.974.004
Tahun13	Rp 5.B76.132.921	Rp 5.711.409.373	Rp 5.789.165.976	Rp 5.922.656.870	Rp 6.077.984.304	Rp 6244.104.709
Tahun14	Rp 6.133.752.047	Rp 5.871.918.289	Rp 5.927.704.763	Rp 6.055.881.838	Rp 6.212.360.464	Rp 6382.810.671
Tahun1S	Rp 6.468.613.950	Rp 6.076.625.956	Rp 6.101.301.838	Rp 6.220.066.752	Rp 6.375.529.381	Rp 6549.IIJ4.523

Figure 4.3 One of output form within Ms. Excel

5. Conclusion and Suggestion

Conclusion

According to the result from software testing, it can be concluded that:

1. MTTR and MTTF calculation already precise and equal to the manual calculation, the differences occurs because of number rounding off.
2. Life Cycle Cost (LCC) Analysis calculation already precise and equal to the manual calculation, the differences occurs because of number rounding off.
3. Output analysis can be easily understood with the help of output per process and bar chart per output pr process.

Suggestion

1. Other module and software/ application added in.
2. For the next research, it can be integrated with another maintenance management method such as Overall Equipment Effectiveness (OEE), Risk Based Maintenance (RBM), and Monte Carlo Simulation.
3. Design can be made more attractive and dinamyc.

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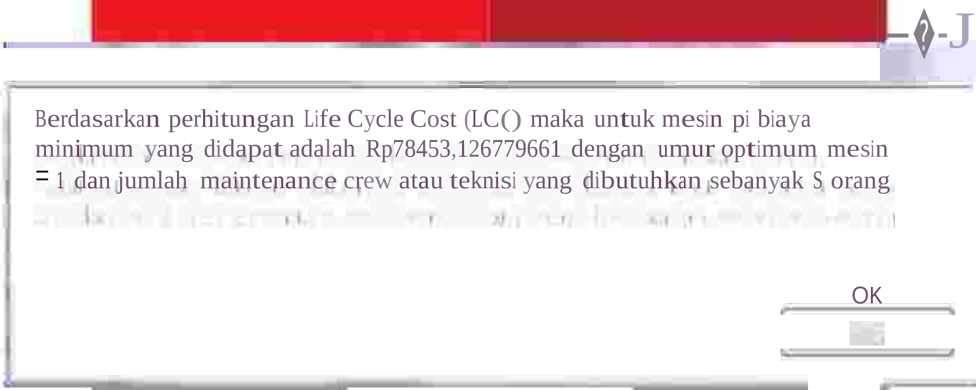
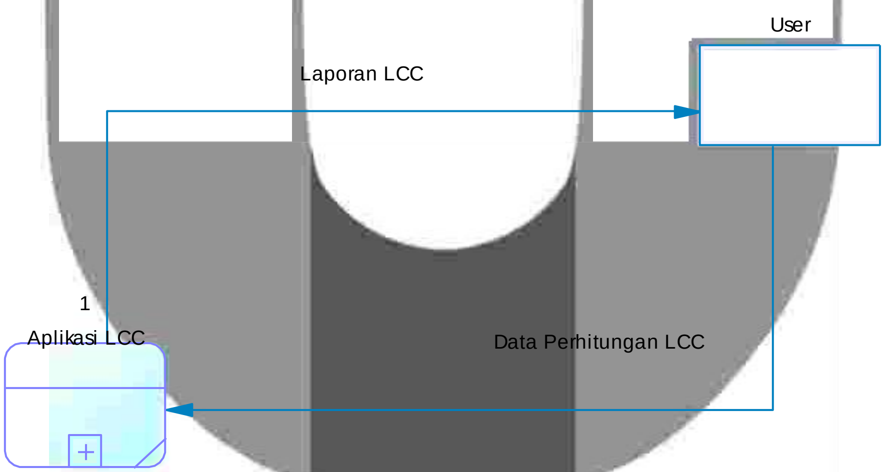
Appendix

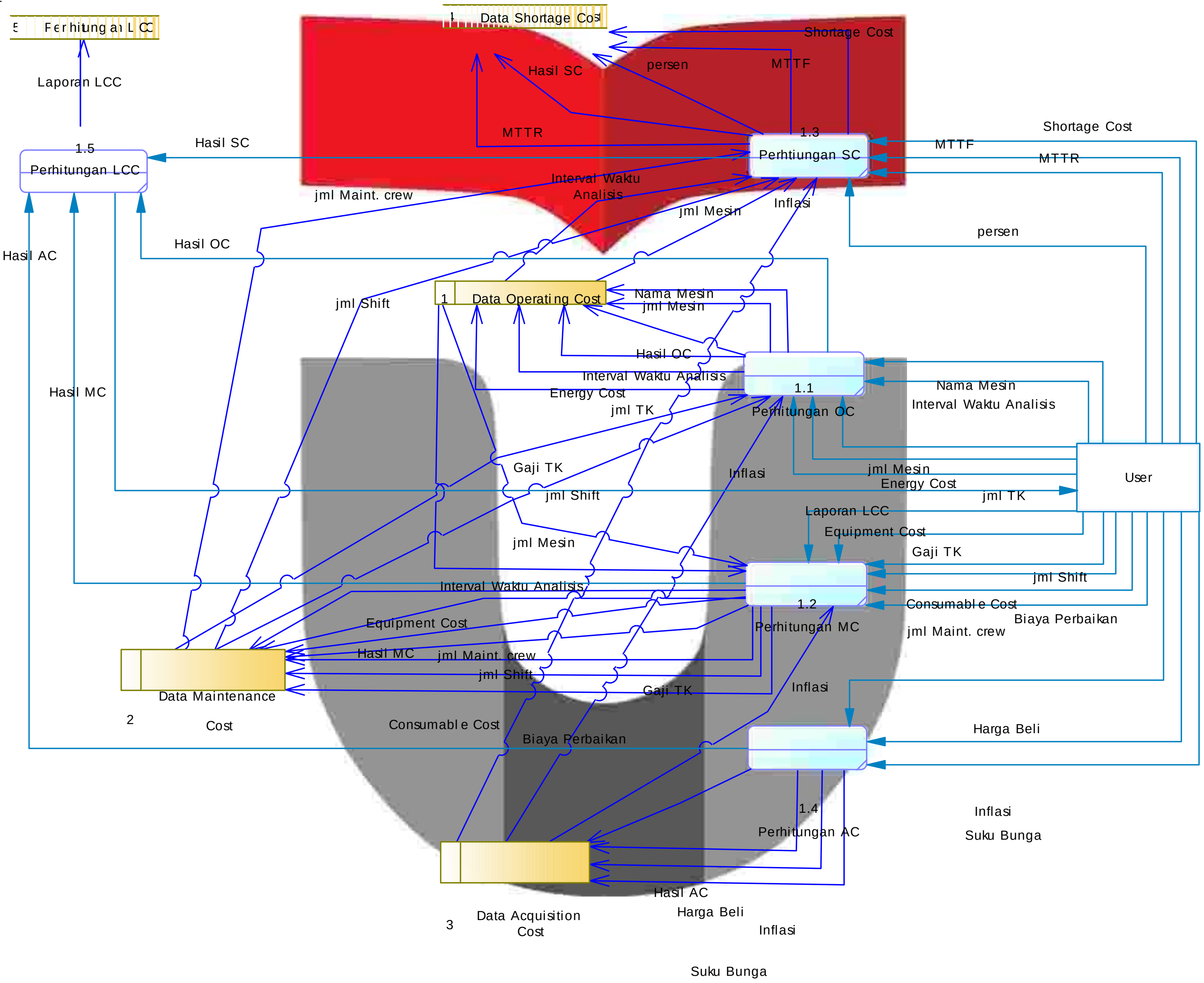
Form Output Message Box



DFD Level 0



DFD Level 1


Data Shortage Cost
Shortage Cost
persen
MTTF
Hasil SC
MTTR
1.3
Perhtiungan SC
Laporan LCC
1.5
Perhitungan LCC
Hasil SC
Interval Waktu Analisis
jml Maint. crew
jml Mesin
Inflasi
Shortage Cost
MTTF
MTTR
persen
Hasil OC
Hasil AC
jml Shift
1 Data Operating Cost
Nama Mesin
jml Mesin
Hasil OC
Interval Waktu Analisis
Energy Cost
jml TK
1.1
Perhitungan OC
Nama Mesin
Interval Waktu Analisis
Hasil MC
Gaji TK
jml Shift
Inflasi
jml Mesin
Energy Cost
jml TK
User
Laporan LCC
Equipment Cost
jml Mesin
Gaji TK
jml Shift
Interval Waktu Analisis
1.2
Perhitungan MC
Consumable Cost
Biaya Perbaikan
jml Maint. crew
Equipment Cost
Hasil MC
jml Maint. crew
jml Shift
Gaji TK
Data Maintenance Cost
2
Consumable Cost
Biaya Perbaikan
Inflasi
Harga Beli
1.4
Perhitungan AC
Inflasi
Suku Bunga
Hasil AC
Harga Beli
Inflasi
3
Data Acquisition Cost
Suku Bunga