DEVELOPMENT OF MANAGEMENT INFORMATION SYSTEM OF PROJECT COST AND TIME IN CV. BINTANG UTARA

Fahmi Hidayat1, Alif Finandhita2

[1.2]Information Engineering - University Computer Indonesia
Jl. Dipatiukur 112-114 Bandung
E-mail: fahmi0907@gmail.com1, alif.finandhita@ email.unikom.ac.id[2]

ABSTRACT

CV. Bintang Utara is a company engaged in construction services provider. CV. Bintang Utara is currently experiencing incompatibility problems weights work plan with weights when working on the project realization work more than one, so it is difficult to determine which projects should be accelerated. Acceleration is usually done at the end of the settlement led to the project manager is difficult to compare costs with a fine acceleration when acceleration is performed directly without waiting for the final completion of the project. The absence of a system that can integrate the process of reporting the progress of work undertaken by the technical implementation. Based on the issue of cost control and time and determining which projects should be accelerated using Earned Value Management. Acceleration is done without having to wait the end of the project, so as to compare the cost of acceleration with a fine using methodTime Cost Trade Off. Critical path used is the Critical Path Method because it can identify critical work included, so it can be accelerated on the job. From the research, management information systems project costs and time can help managers determine which projects should be accelerated telebih first. The system can help project managers to compare the costs of acceleration and fines based on information costs and time. Management information system costs and time can help integrate the reporting process work undertaken by the technical implementation.

Keywords: *Management Of The Cost and Time Project, Project Acceleration, Earned Value Management, Critical Path Method, and Cost Trade Time Off.*

1. INTRODUCTION

CV. Bintang Utara is a company engaged in construction projects such as building and strengthening, and maintenance of roads, construction and renovation of houses and construction of the bridge.

Based on interviews conducted with Mr. Roni Iskandar as Project Manager explained that CV. North staris currently working on more than one project, namely Roads and Drainage Project Normalization Proyek Normalisasi Drainase Jalan In Region I s / d VIII Kebinamargaan Services Unit. Work on both projects run into problems, namely the incompatibility between the weight of work per week are planned with the weight of work per week were realized. Weights that do not fit can be seen in the data reports Normalization Project Drainage Street Week 2 only amounted to 2.879% from 5.759% planned. As for Proyek Normalisasi Drainase Jalan In Region I s / d VIII Kebinamargaan Care Unit at week 1 only amounted to 0.104% from 0.260% planned. The project manager difficulty in determining which projects should be accelerated prior to the project under construction, because there is not currently a reference in determining which projects should be accelerated. If the determination of the project should be accelerated wrong, it can cause project costs to swell with increasing duration of the project.

The project manager difficult to make a comparison between the cost of acceleration that will be paid with a late fee to be paid, because the acceleration is usually done when the project approached the project Completion time project according to plan. The absence of a system that can mengintegraskan process of reporting the progress of work performed by the technical implementation becomes a problem in itself, because it can causing slow process of evaluation made by the project manager, so if there is deviation cost or time action is taken to be blocked.

Based on the problems that have been described, then a management information system costs and the time it is expected to facilitate the project manager in controlling the cost and time of the project, determine project should be accelerated in advance if there are problems on

the two projects or more, as well as analyze the work that is critical of a project to the next to be accelerated, and can integrate the process of sending the progress report of work performed by the technical implementation to the project manager.

2. CONTENT OF RESEARCH

2.1 *Analysis Earned Value Management*

Controlling costs and time by using Earned Value Managment, there are some values that are needed in the process, namely Planned Value (PV), Earned Value (EV), Cost Variant (CV), Schedule Variant (SV), Cost Performance Index (CPI) , Schedule Performance Index (SPI), Estimate Actual Completion (EAC) and the Estimate Time Completion (ETC). The project manager can draw conclusions bedasarkan ETC and EAC calculation of the running project [1]. EVM calculation is used in two projects namely normalization project drainage at week 2, and Proyek Normalisasi Drainase Jalans at week 1.

2.1.1 *Calculation of Planned Value (PV) Normalisasi Drainase Jalan Project*

Calculation of Planned Value (PV), which identifies the weight of the plan every week based on weight information from the plan table 1.

Table 1 Project Time Schedule Normalisasi Drainase Jalan

Week	*Planning*
1	*3,153*
2	*5759*
3	*5759*
4	*20 917*
5	*20 917*
6	*20 917*
7	*20 917*
8	*1,660*

Planned Value (PV) derived from the weight of the plan every week multiplied by Budget Actual Cost (BAC). BAC is the value of the contract without VAT is Rp. 87,209,941.75 rounded to Rp. 87.2099 million. Here is the result of the calculation of Planned Value (PV) at week 1:

PV = (% progress plan) x BAC
= 3.153% x 87.2099 million
= 2749729

For PV calculation results in the next week can be seen in Table 2.

Table 2 PV Calculation Results

Week	% Plan	PV (Rp)	Cumulative (Rp)
1	3,153	2749728	2749728
2	5759	5022418	7772146
3	5759	5022418	12,794,564
4	20 917	18,241,695	31,036,259
5	20 917	18,241,695	49,277,954
6	20 917	18,241,695	67,519,649
7	20 917	18,241,695	85,761,344
8	1.66	1447684	87,209,028

2.1.2 *Calculation of Earned Value (EV) Normalization Project Drainage Street*

Calculation Earned value (EV) is to identify the actual weight of each week based on the actual weight information in Table 3.

Table 3 Project Weekly Report Normalisasi Drainase Jalan

Week	*Actual*
1	*3,153*
2	*2,879*

EV calculation is only used in week 1 to week 2. Earned value (EV) obtained from the actual weight for each week worked multiplied by Budget Actual Cost (BAC). Here is the result of the calculation of Earned Value (EV) at week 1:

EV = (% actual progress) x BAC
= 3.153 x 87.2099 million
= 2749728

For EV calculation results in the next week can be seen in Table 4.

Table 4 EV Calculation Results

Week	% Actual	EV (Rp)	Cumulative (Rp)
1	3,153	2.749.728	2.749.728
2	2,879	2.510.773	5.260.501

2.1.3 *Calculation CV and SV Normalisasi Drainase Jalan Project*

Calculation of costs or Cost variants Variant (CV) is to identify deviations costs incurred, whether more efficient or even more than the value of contracts that have already been determined. CV is calculated from the number of EV - AC. Schedule Variant (SV) is to identify whether the time worked will be in accordance with the timetable, faster or even late on a fixed schedule. SV calculation derived from EV - PV.

Here are the results of calculation of the CV and SV in week 1:

CV = EV - AC
= 2749728-2749728
= 0
SV = EV - PV
= 2749728-2749728
= 0

For CV and SV calculation results in the next week can be seen in Table 5.

Table 5 Calculation results of CV and SV

Minggu Ke	CV	SV
1	0	0
2	0	- 2.511.645

2.1.4 *The calculation of the CPI and SPI Normalisasi Drainase Jalan Project*

Cost Performance Index (CPI) shows weight values obtained against the costs incurred. CPI is derived from the calculation of EV / AC, because AC value equal to the value issued for each job, it could be inferred AC values equal to EV. Schdule Performance Index (SPI) shows how much work that can be completed to the planned work, SPI acquired from the calculation of EV / PV [1].

Here are the results of calculation of Cost Performance Index (CPI) and Schedule Performance Index (SPI) Week 1:

CPI = EV / AC
= 22.27254 million / 22.27254 million
= 1
SPI = EV / PV
= 22,272,540 / 22,272,540 = 1

For the calculation of CPI and SPI results in the next week can be seen in Table 6.

Table 6 Calculation results of the CPI and SPI

Minggu Ke	CPI	SPI
1	1	1
2	1	0.5

2.1.5 *Calculation of EAC and ETC Proyek Normalisasi Drainase Jalan*

EAC calculation is bagimana penyerlesaian project cost estimates. EAC calculation based on the value of the BAC divided by Cost Performance Index (CPI). ETC calculations derived from the agreed contract period divided by the Schedule Performance Index (SPI) [1][4].

Here is the result of calculations Estimate Actual Cost (EAC) and the Estimate Time to Complete (ETC) at week 1:

EAC = BAC / CPI
= 87.2099 million / 1
= 87.2099 million
ETC = OTE / SPI
= 60/1
= 60

For the calculation result EAC and ETC in the next week can be seen in Table 7.

Table 7 Calculation results of EAC and ETC

Minggu Ke	EAC	ETC
1	87.209.900	60
2	87.209.900	120

2.1.6 *Results Summary of EVM method Normalisasi Drainase Jalan Project*

Here is a recap of the results of the analysis methods Earn Value Management (EVM) as shown in Table 8.

Table 8 EVM Analysis Recapitulation

Weeks	Analysis of Variance		Work analysis		Estimates analysis	
	SV	CV	SPI	CPI	ETC	EAC
1	0	0	1	1	60	87.209.900
2	-2,511,645	0	0.5	1	120	87.209.900

Based on the information in Table 7, it can be concluded on the 2nd week of the project is not in accordance with the plan. This can be seen in the value of -2,511,645 SV or SV <0. The ETC does not correspond to the planned duration of the project, ETC generated is equal to 120 days over 60 days from the planned beginning of the project duration is equal to 60 days and costs issued by Rp.87.209.900, equal to the total budget (BAC). S-curve road drainage project normalization can be seen in Figure 1 below.

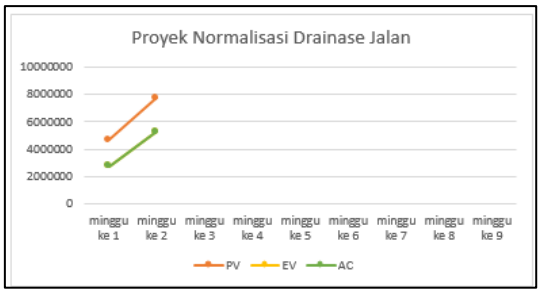


Image 1 S-curve Normalisasi Drainase Jalan Project

2.1.7 *Calculation of Planned Value (PV) Normalisasi Drainase Jalan Project*

Calculation of Planned Value (PV), which identifies the weight of the plan every week based on weight information plan from table 9.

Table 9 Time Schedule Pemeliharaan Rutin Jalan Project

Sunday	*weights Plan*
1	*10 446*
2	*4,607*
3	*4,067*
4	*35 394*
5	*35 394*
6	*9533*

Planned Value obtained from the weight multiplied by the plan each week Budget Actual Cost (BAC). BAC is the value of the contract without VAT is Rp. 45.0139 million. Here is the

result of the calculation of Planned Value (PV) at week 1:

PV = (% progress plan) x BAC
= 10 446 x 45.0139 million
= 4702152

For PV calculation results in the next week can be seen in Table 10.

Table 10 PV Calculation Results

Week	% Plan	PV (USD)	Cumulative (USD)
1	10 446	4702152	4.702.152
2	4,607	2.073.790	6.775.942
3	4,607	2.073.790	8.849.733
4	35,394	15.932.220	24.781.953
5	35,394	15.932.220	40.714.172
6	9.553	4.300.1780	45.014.350

2.1.8 *Calculation of Earned Value (EV) Pemeliharaan Rutin Jalan Project*

Calculation of Earned Value (EV) is to identify the actual weight of each week based on the actual weight information table 11.

Table 11 Weekly Report Pemeliharaan Rutin Jalan Project

Sunday	*Actual weights*
1	*10:29*

EV calculations hanya used in week 1. EV obtained from the actual weight of each week worked multiplied by Budget Actual Cost (BAC). Here is the result of the calculation of Earned Value (EV) at week 1:

EV = (% progress plan) x BAC
EV = 10.29 x 45.0139 million
= 4.63193 million

For EV calculation results can be seen in Table 12.

Table 12 EV Calculation Results

Minggu Ke	% Aktual	EV (Rp)	Komulatif (Rp)
1	10.290	4.631.930	4.631.930

2.1.9 *CV and SV Calculation Pemeliharaan Rutin Jalan Project*

Cost variance analysis cost or variant (CV) that identifies penyimpangan costs. Schedule schedule variance analysis or variant (SV) is to identify whether the time is done later in accordance with the schedule, faster or even delayed. SV calculation derived from EV - PV [1]. Here are the results of calculation of the CV and SV in week 1:

CV = EV - AC
= 4631930-4631930
= 0
SV = EV - PV
= 4631930-4702152
= -70 222

For CV and SV calculation results in the next week can be seen in Table 13.

Table 13 Calculation results of CV and SV

Minggu Ke	CV	SV
1	0	-70.222

2.1.10 *The calculation of the CPI and SPI Pemeliharaan Rutin Jalan Project*

Cost Performance Index (CPI) shows weight values obtained against the costs incurred. CPI is derived from the calculation of EV / AC. Schedule Performance Index (SPI) shows how much work that can be completed to the planned work, SPI acquired from the calculation of EV / PV [1][3].

Here are the results of calculation of Cost Performance Index (CPI) and Schedule Performance Index (SPI) Week 1:

CPI = EV / AC
= 4.63193 million / 4.63193 million
= 1
SPI = EV / PV
= 4.63193 million / 4702152
= 0985

For the calculation of CPI and SPI results can be seen in table 14

Table 14 Calculation results of the CPI and SPI

Minggu Ke	CPI	SPI
1	1	0.985

2.1.11 *Calculation of EAC and ETC Pemeliharaan Rutin Jalan Project*

EAC calculation is bagimana cost estimates based on the BAC shared with performance fees (CPI). ETC calculations derived from the agreed contract period divided by the performance schedule (SPI) [1][3].

Here is the result of calculations Estimate Actual Cost (EAC) and the Estimate Time to Complete (ETC) at week 1:

EAC = BAC / CPI
= 45.0139 million / 1
= 45.0139 million
ETC = OTE / SPI
= 45/1
= 46

For EAC and ETC calculation results can be seen in Table 15.

Table 15 Calculation results of EAC and ETC

Minggu Ke	EAC	ETC
1	45.013.900	46

2.1.12 *Results Summary of Analysis EVM Methods Pemeliharaan Rutin Jalan Project*

Here is a recap of the results of the analysis method of Earned Value Management (EVM) as shown in Table 16.

Table 16 Results Summary of Analysis of EVM

Weeks	analysis of Variance		Work analysis		Estimates analysis	
	SV	CV	SPI	CPI	ETC (days)	EAC (USD)
1	-70 222	0	0985	1	46	45.013.900

From EVM analysis recap the results in Table 16, be concluded that the project is not in accordance with the plan, with a value estimated time of completion (ETC) is 46 days, one day longer than the duration of the project is 45 days and costs Rp. 45.0139 million, equal to the total budget (BAC). Spi value <1 indicates the project has been delayed, Cpi value is 1 indicates the cost is equal to the planned costs. S-curve for Proyek Normalisasi Drainase Jalans can be seen in Figure 2 below.

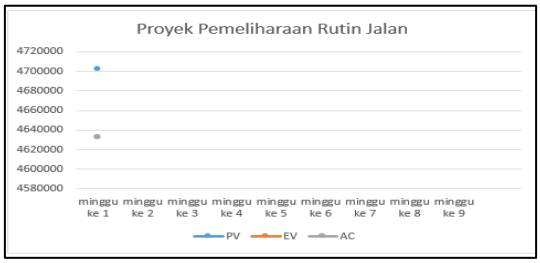


Image 2 S-curve Proyek Normalisasi Drainase Jalan

2.1.13 *Conclusion Methods of EVM*

Conclusion The method of EVM can be seen in Table 17.

Table 17 Comparative Analysis of EVM

Project	First plan		EVM analysis		Difference	
	Day	Cost (without VAT 10%)	ETC	EAC	Day	Cost
Normalization Drainage Street	60	87.209.900	120	87.209.900	60	0
Routine Maintenance Road	45	45.013.900	46	45.013.900	1	0

Based on the information in Table 17, it can be concluded that the acceleration of projects that should be done first is the normalization Drainage project Jalan Dusun, based on the value Estimate Actual Cost (EAC) for Normalization project amounted Rp.87.209.900 Road Drainage and value Estimate Time to Complete (ETC) is approximately 120 days.

2.2 *Critical Path Analysis Method*

Critical Path Method (CPM) is a method of project scheduling labor based on a network diagram that shows the critical path during the project work[2], The data required in the analysis of CPM ie Work Breakdown Structure (WBS) and details of the project execution time Normalization Drainage Street.

Table 18 Details of ProyekNormalisasi Drainase Jalan

No	URAIAN PEKERJAAN	LAMA PENGERJAAN	MULAI	SELESAI
1	2	3	4	5
I.	PEKERJAAN PERSIAPAN			
1	Direksikeet	7 hari	25/08/2017	31/08/2017
2	Pasang Papan Nama Proyek	1 hari	25/08/2017	25/08/2017
Total			25/08/2017	31/08/2017
II.	PEKERJAAN KONSTRUKSI SALURAN			
1	Galian Tanah (Manual)	14 hari	01/09/2017	14/09/2017
2	Pas. Batu ad. 1:4 (Plesteran Acian)	28 hari	15/09/2017	12/10/2017
3	Timbunan Tanah Pilihan	10 hari	13/10/2017	23/10/2017
Total			01/09/2017	23/10/2017

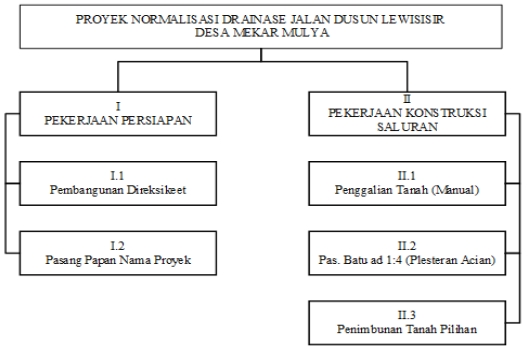


Image 3 Normalisasi Drainase Jalan

WBS Normalization

From the information in Table 18 and Figure 3 is then determined predecessor jobs and job code. The work that has been analyzed predecessors can be seen in Table 19.

Table 19 Predecessor

No.	*Job description*	*Employment code*	*predecessor jobs*	*duration*
1	*Direksikeet*	*I.1*	-	*7 days*
2	*Posting Board Names*	*I.2*	-	*1 day*
3	*Soil excavation*	*II.1*	*I.1, I.2*	*14 days*
4	*Pas. Stone*	*II.2*	*II.1*	*28 days*
5	*Soil heap Options*	*II.3*	*II.2*	*10 days*

2.1.1 *Forward Calculation*

Advanced calculations performed early starts moving up towards the end tissue tissue [2]. Here is an initial calculation to find the value of ES (early start) and EF (early finish) at I.1 Occupation:

1. $ES = = 0 + 0 = 0$ daysES_1
   $EF = = 0 + 7 = 7$ daysES_1

From the calculation in a job obtained ES and EF values are 0 and 7. Following the results of recapitulation of Public Works I.1 till II.3, can be seen in table 20.

Table 20 Forward Calculation

Employment code	Work		Time (t)	The first	
	i-node	j-node		Start (ES)	Finish (EF)
I.1	-	1	7	0	7
I.2	-	2	1	0	1
II.1	1	3	14	7	21
II.2	3	4	28	21	49
II.3	4	5	10	49	59

2.1.2 *Backward Calculations*

Countdown carried out starting from the end towards the beginning of the network until the network [2][5].

Here is an initial calculation to find the value LS (last start) and LF (last finish) on II.3 Occupation:

1. *LS = = 59-10 = 49 daysLF_{4-5}*
   LF = = 59 daysLF_{4-5}

Works from the calculation in E obtained the LS and LF are 49 and 59. Following the results of recapitulation of Public Works I.1 II.3 up, can be seen in table 21.

Table 21 Backward Calculations

Employment code	Work		Time (t)	The last	
	i-node	j-node		Start (LS)	Finish (LF)
I.1	-	1	7	0	7
I.2	-	2	1	6	7
II.1	1	3	14	7	21
II.2	3	4	28	21	49
II.3	4	5	10	49	59

2.1.3 *Slack Calculation / Float*

Slack or Float is the amount of time delay is allowed without affecting the total time of the project [2].

Here is the calculation of the total float on Works I.1:

TF = TF 1-2.1 = 7-7 = 0

Float calculation results can be seen in Table 22.

Table 22 calculation Float

Employment code	Time (t)	The first		The last		total Float
		Start (ES)	Finish (EF)	Start (LS)	Finish (LF)	
I.1	7	0	7	0	7	0
I.2	1	0	1	6	7	6
II.1	14	7	21	7	21	0
II.2	28	21	49	21	49	0
II.3	10	49	59	49	59	0

Based on information from table 22, we can conclude is the critical path I.1 - II.1 - II.2 - II.3, Of the data is then depicted in the form of a network diagram as shown in Figure 4.

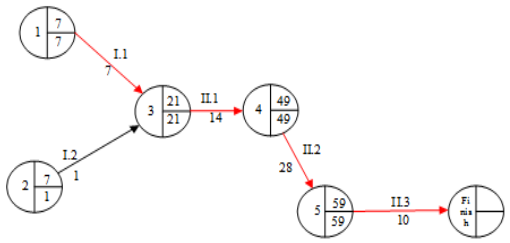


Image 4 Critical Path Network Diagram

2.1.4 *Conclusion Analysis of Critical Path Method (CPM)*

Normalization Project Drainage Street has a duration of 59 days during the critical path of the normal duration for 60 days. Workcan be seen in Table 23.

Table 23 Conclusion CPM

Employment code	*Name of Job*	*Duration Critical Path*	*Duration Normal*
I.1	*Direksikeet*	*59*	*60*
I.2	*Soil excavation*		
II.3	*Pas. Stone*		
II.4	*Soil heap Options*		

2.3 *Analysis of Time Cost Trade Off (TCTO)*

Acceleration projects with optimization of time and cost on Road Drainage Project Normalization using Time Cost Trade Off (TCTO). Acceleration time and costs are calculated by adding alternative working hours centered on the work that is on the critical path [2][6].

2.3.1 *Calculation of Normal Daily Productivity*

In general, the daily productivity is calculated by the following formula:

$$\text{Produktivitas harian normal} = \frac{\text{Volume Pekerjaan}}{\text{Durasi Normal}}$$

Calculation of normal daily productivity on the job Soil excavation, with ketentutan 1 working day is 8 hours.

Job volume = 122.33 m3
normal duration = 14 days
normal productivity = 122.33 / 14
= 8,73 m3

2.3.2 *Calculation Productivity Acceleration*

The following daily calculation acceleration Excavated soil should be accelerated.

a. Normal working hour = 8 Hours
b. Extra hours (overtime) = 1 hour
c. overtime pay = 1.5 wages
d. worker productivity = 90%
e. Normal daily productivity = 8,73 M3
f. Normal daily productivity / hour = 8,73 / 8
= 1:09 M^3
g. Productivity overtime
= (1 x 0.9) x 1:09 M3
= 0.98 M3
h. Daily productivity acceleration
= 8.73 + 0.98
= 9.71 M3

2.3.3 *Calculation Crash Crash Duration and Cost*

Here is the calculation duration Crash, Crash cost:

a. Job volume = 122.33 M^3
b. normal duration = 14 days
c. The normal cost = 10,044,516.30
d. The unit cost of wages = 27,000
e. The unit cost tools = 21,000
f. Normal daily productivity = 8,73 M3
g. productivity acceleration = 9.71 M3
h. crash duration = 122.33 / 9.71
= 12.6 days or 12 days
i. Normal wage / hour = 27,000
j. Normal wage / day = 8 hours xi
= 8 x 27,000 = Rp. 216,000
k. Overtime pay / day = 1.5 x 27,000
= Rp. 40,500
l. Wage costs / day = 216,000 + 40,500
= 256 500
m. The total cost of wages = 12 x 256 500
= Rp. 3.078.000
n. The total cost of the tool = 21,000
o. crash cost
= 3.078.000 + 21.000 + 10.044.516,30
= Rp. 13.143.516,30
p. cost slope

$$= \frac{13.143.516,30 - 10.044.516,30}{14 - 12}$$

= Rp. 1.549.500,00

2.3.4 *calculation of Fines*

Calculation of fines project as follows:

$$Denda = \frac{1}{1000} \times 95.930.000$$

= Rp. 95 930 / day

Delays generated based on the calculation of the EVM is 60 days, then the calculation of fines as follows:

Fine = 60 x Rp. 95 930
= Rp. 5.7558 million

2.3.5 *Conclusion Analysis of Time Cost Trade Off (TCTO)*

Road Drainage Project Normalization can be completed on time ie for 60 days by adding a fee of Rp. 3,099,000.00 so that the total project cost of Rp. 99.029 million. to more clearly seen in Table 24.

Table 24 conclusion TCTO

Proyek	Durasi (Hari)	Nilai Proyek (Rp)	Biaya Percepatan	Terlambat (Hari)	Denda (Rp)	Biaya Total (Rp)
Proyek Normalisasi Drainase Jalan	120	95.930.000	0	60	5.755.800	101.685.800
	60	95.930.000	3.099.000	0	0	99.029.000

3 CLOSING

3.1 Clonclusion

Based upon the results of research and testing has been done to the Management Information System Cost and Time Jobs at CV. North Star, can be deduced as follows:

1. *Information management system costs and project time management, can help assist project managers in determining which projects should be accelerated in advance.*
2. *Management information system management costs and project time, can help project managers to compare the cost of acceleration with a late fee to be paid based on the information of cost and time, so as to determine what steps should be taken to ensure the project is done can be completed on time with the final cost of the project not too big.*
3. *Information management system costs and project time management, can help integrate the process of reporting the progress of work undertaken by the technical implementation, so expect the evaluation process is not hampered.*

3.2 suggestion

based on sisterm test results, there is a suggestion to add a few things that can complement da Cost Management Information System Project Time in the future, among other things:

1. *Adding features progress data changes automatically when the project progress to be accelerated.*
2. *Adding features change the critical path of a project when there is a delay, in order to*

maintain the project so it can be completed as planned.

3. *Least cost analysis adds features so it can be the most minimal project costs and the optimal duration of the project.*

BIBLIOGRAPHY

[1] *Husen.Abrar, Manajemen Proyek perencanaan, penjadwalan dan pengendalian proyek, Yogyakarta: Andi Offset, 2009.*

[2] *Suharto. Imam, Manajemen Konstruksi (Dari konseptual sampai operasional), Jakarta: Erlangga, 1999.*

[3] *A. Pamungkas, Sugiarto dan Setiono Desember 2013, "Analisis Nilai Hasil Terhadap Waktu dan Biaya Pada Proyek Konstruksi. Studi Kasus: Proyek ICB Civil Work Construction off Spilway of Countermeasure for Sedimen in Wonogiri". e-Matriks Teknik Sipil. Vol. 1, no.4, pp 417.*

[4] *C. Sandy dan D. Irianto Januari, 2015, "Pengendalian Waktu Dan Biaya Pada Proyek Pembuatan Saluran Terbuka". e-Matriks Teknik Sipil. Vol. 1, no.9, pp 200-215.*

[5] *M. Rizki Ridho dan Syahrizal "Evaluasi Penjadwalan Waktu dan Biaya Proyek dengan Metode PERT dan CPM. Studi Kasus: Proyek Pembangunan Jembatan Cijapati". e-Matriks Teknik Sipil. Vol. 1, no.4, pp 417.*

[6] *A. Maddepungeng, I. Suryani, dan D. Hermawan, 2015, "Analisis Optimasi Biaya dan Waktu dengan Metode TCTO (Time Cost Trade Off). Studi Kasus: Proyek Pembangunan Pasar Petir Serang Banten". Foundasi. Vol. 4, no.1.*