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Improvement of Information and Communication Technology (ICT) Maintenance in Government Institution using Hybrid of Six Sigma and Several Decision Support Methods

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Abstract*: *Nowadays, the development of ICT devices is growing very rapidly. Many companies and governments invest a lot of funds on the ICT side to optimize and cut operational costs as effectively and efficiently as possible. This paper discussed the issue of the maintenance of ICT equipment in the Indonesian constitutional court which is spread in 42 locations throughout Indonesia. The current problem is that there is no maintenance of ICT in the Constitutional Court of the Republic of Indonesia in 42 cities throughout Indonesia, so it is difficult to overcome the technical problems that occur. In this paper, Six sigma is combined with several decision-making methods to minimize technical disturbances in the ICT device to the right selection of vendors to carry out the ICT maintenance. The proposed method that we did to optimize maintenance services using a hybrid DMAIC six sigma which then improved the quality of analysis using brainstorming and decision making on the best vendors using AHP. The hybrid of six sigma is very instrumental in reducing the weakness of six sigma which forces the process of monitoring diligently and continuously. This research yielded better service quality compared to the current system for maintenance ICT at the Indonesian Constitutional Court.

Keywords* : *Six Sigma, ICT Maintenance, IT Services, Pareto Diagram, Ishikawa Diagram, Brainstorming, Analytical Hierarchy Process.

I. INTRODUCTION

All organizations and companies require maximum profits by reducing costs, shortening production time, and minimizing production defects to as minimum as possible. Inflation that often occurs every year and the ups and downs of the prices of basic production materials make the company leaders have to keep on twisting the brain to streamline spending without reducing the quality and quantity of production [1]. Many methods are related to controlling the quality of the company's production, but Six Sigma can analyze it more deeply [2]. Most of the strategies used are only to create a zero-error strategy without considering many parameters, one of which is related to production time which should not be hampered. For large-scale companies, losing a few seconds is fatal in the production process. Operations play an important role in the life cycle of the company [3].

A. IT Services.

IT Services is a service that is used to meet the needs of consumers to increase effectiveness and efficiency in providing services to consumers. Information technology has now become the primary need of the company in carrying out its business operations due to the efficiency of the company's expenses and of course its relation to customer satisfaction. Therefore, three things determine the success of companies in implementing information technology, namely [4]:

- People, it called customers, service/product users, information technology managers, company management including the owner;
- Process, the methodology which used to be standard operating procedure and business;
- Product, it's a part which consumed by customers and users.

IT Services is located in the process because it covers the company's business processes, operations, services to consumers, improvements and evaluations. There are many methodologies used in the IT Services process, but this paper will focus on Six Sigma. Why? Because the main thing that becomes the focus of analysis is the process that is currently running compared to the proposed method that will be used. Of course, the parameters in the current conditions and proposals must be determined so that the calculation is done right. Explanation of the process outlined must be clear because it is related to the supporting data used to calculate. The main objective is to deliver the proposed method to meet company objectives. Of course, all stakeholders involved in IT Services have their respective roles and responsibilities that are interconnected with the company's business processes. Besides, it also needs to be considered whether there is an involvement of the external party of the company in the running business process so that the calculation is done right [5].

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The weakness of Six Sigma is that it takes a long time to analyze all the processes that exist to become a framework that changes business processes for the better. This does not include the decision making process.

Therefore, this paper discusses the hybrid of six sigma process with several sequential decision-making methods, so that the resulting framework not only produces the framework of the results of the analysis, but also presents the appropriate decision making vendor to maintain the maintenance of the ICT.

B. ICT Maintenance.

Information and Communication Technology's (ICT) Maintenance is a method that deals with change management, which is a process that has the responsibility to control the cycle of every change (change) that occurs. The main objective is to implement better operations and services by minimizing disruptions. Change Management is divided into two, namely [6]:

- Proactive, the goal is to get the benefits that are used to support the company's business interests including improving services to stakeholders in it and making IT services more effective and efficient;
- Reactive, for this reason, the goal is to solve the problems that occur including adapting to a changing environment. Examples of organizational change (organizational restructuring) certainly make some services change business processes.

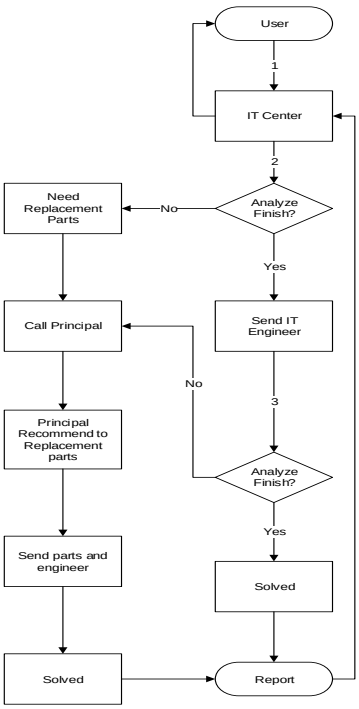

Fig 1. Current Maintenance flow

ICT Maintenance this time includes maintenance of all IT equipment both inside the data center and outside. There are two types of equipment maintained, namely infrastructure (hardware) and license (software). Both types of equipment are interrelated and will hamper IT operations if one does not go well [7].

As the case study, Government Court institution in Indonesia is considered. The current flow of ICT maintenance in the institution as described in Fig.1. It explained that was a gap in the first analyze step. In daily operations of the data center and all devices cannot be separated from maintenance activities. The flow is begun with the user's complaint to the IT center. The IT center will ask the operator representatives to identify the condition and the root cause of the problem. Based on the report, there are 2 possibilities:

- the IT center will send the IT engineer from the headquarter to solve the problem on-site;
- the IT center has to contact the principal if replacement parts are needed. Then, the principal will send required engineer to replace the broken parts.

The problem is both of steps above are done without a clear standard procedure and the decision depends on the Head of Information Technology. If the IT Engineer who sent to the location could not solve the problem, they will contact the principal's engineer especially when the parts should be replaced. Principal's engineer will be sent to the location solving the problem and if it needs to change the parts, they will request to their office sending the parts to the location and they will come again to change the parts after it arrives. So, it takes many times waiting for the replacement parts from order to arrive to the location. It does not comply the availability in IT Services [8].

The ICT Maintenance cannot be done on the data center which began operating in 2006 due to the absence of human resources who have technical knowledge about ICT, the Standard Operating Procedure (SOP) has not done yet, and the unavailability of state maintenance budgets. In this paper, we will calculate which is the best method between brainstorming and Pareto-Ishikawa to choose using vendor or engineer's employee. In improve steps, we can improve the system that is running with the system that we are proposing. The result from that steps will be decided using Analytical Hierarchy Process (AHP) choosing which is the best vendor for the institution. Six sigma cannot analyze business processes independently to produce a new framework. Therefore, six sigma needs to be hybridized with several decision-making methods such as brainstorming and Analytical Hierarchy Process (AHP).

II. RELATED WORK

We found many papers that discussed methods of using Six Sigma to help add to the work already done viewed in Table.1. Mancosu et al. used Lean Six Sigma Methodology in radiotherapy and explained that DMAIC six sigma could be implemented and allowed to redesign breast repositioning matching procedure [9].

In a hospital environment, management evaluation periodically represents something that has become an important culture to always provide continuous improvement. One of them is discussed by [10] regarding to evaluation and improvement of hospital operational management using the six sigma method to streamline operational costs. It began with an investigation at Hartford Hospital regarding an intravenous device that was used to enter the drug by injecting it into a vein because the injection became waste.

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Therefore, the Hospital Team observed, measured performance, and analyzed root causes related to the policy of intravenous use, practice, and equipment used to minimize the use of injections which became hazardous waste.

Six Sigma methods are used to define, measure, analyze, improve, and control the use of intravenous injections based on patient data and disease management procedures that require intravenous use with a focus on minimizing the use of intravenous injections. During the 26 months of the study, Hartford Hospital experienced a 69% decrease in the use of intravenous injections including the use of plasminogen activators with savings of US $ .107,315, - during this period. So that it can be concluded from the research conducted that the use of Six Sigma for hospital operational management results in better savings.

One of the Case Study papers of Six Sigma methodology in the industry scope that explains several problems in the world of industry is always related to productivity and quality control. Obstacles found in company productivity will directly affect the company's target [11]. Six Sigma implementation is divided into several stages, namely defining, measuring, analyzing, improving and controlling can be abbreviated as DMAIC. Six Sigma DMAIC is a program that focuses on customers where the work team aims to increase customer satisfaction. The philosophy and methodology is to improve the quality of the industry by analyzing data to find the root causes of quality including applying controls within the company. DMAIC stages are used to measure and eliminate variables that are not so necessary, to optimize industrial operations and reduce costs. Although this method is used in industrial scope, it can also be used to evaluate systems that are running to correct deficiencies. This is closely related to the strategy of improving the company's business. This paper explains that the Six Sigma method can improve process performance from critical operational processes to be better with the utilization of company resources, reduce unnecessary operational variables, and maintain the quality of production consistently. Related to the measurement to find out the optimization of operational parameters is done by finding response (y) value, target (d) achievement. After that, Sigma Level Calculation was carried out after the optimization process was carried out.

The implementation of the Six Sigma methodology was also carried out in the socks industry in Bangladesh. Of the many aspects of the quality of any product or service, Six Sigma is one of the promising methods of branding and packaging Over time, this method carries different meanings from various points of view. Therefore it refers to its philosophy, the tools and steps used by Six Sigma to find and eliminate the causes of production errors in a company's business process focusing on output that is important to the customer. Six Sigma analysis can focus on every element of production or service and has a strong emphasis on statistical analysis in customer-oriented design, manufacturing, and industrial activities [12].

Apart from the widespread implementation of organizations using the Six Sigma method, there are increasing concerns about failures that can occur. One reason why many Six Sigma methods fail is because implementation related to the implementation carried out in the field is less mature. To apply Six Sigma according to the analysis, there are several steps that we must go through. First, the analysis strategy carried out must be based on real data in the field and information from customers. Second, make a level, a team that moves to encourage the development/improvement of the organization. Third, identify equipment related to the organization's current operations. Fourth, processing the identification that has been done by mapping the organization and the improvements that can be applied to the organization. Fifth, reduce planning that has been approved at the earliest operational level to be in line with management. Sixth, apply the analysis that has been made, document all implementations, and revise components as needed. The data analyzed comes from various sources which are evident from the organization's operations so that the truth can be accounted [13]. The paper succeeded in applying the Six Sigma method for companies engaged in Network Technology. The resulting model effectively guides the implementation of Six Sigma programs to reduce variations of waste generated from the company's operations. This is very relevant because the current competitive environment forces companies to reduce operational waste to meet the requirements of production efficiency and input from customers.

The maintenance efficiency in the company relates to the company's business continuity. This is alleged to be a burden for companies, especially those whose operations are largely dependent on machinery for the production process. This literature review discusses the contributions that can be made to optimize the company's strategy in implementing maintenance. Maintenance covers various fields such as transportation, housing, cars, manufacturing, and construction (factories, housing, highways, railways, MRT, etc.). Seeing the many fields that require maintenance, in-depth analysis is needed to optimize and streamline maintenance costs that must be spent. For this reason, to ensure the continuity of the business, the credibility, contribution and competence of the company in the market, maintenance must always adapt to the advances in technology and corporate organizational restructuring. Therefore Six Sigma methods are used to help reduce unnecessary costs for the company to optimize the revenue and quality of the company's production. Company management called Lean can be interpreted as a flexible company that has a relationship of performance (quality and production) with the flexibility of a company that should be able to optimize and maintain the entire operational process. The company leaders want the company's performance to constantly increase and continue to increase by reducing unnecessary costs. Company performance (in terms of quality, flexibility, time and cost) is an aggregation of activities carried out. Therefore the application of Six Sigma to maintenance requires good knowledge of the process by using many tools based on statistical techniques [14].

Table 1. Summary of Related Works.

Num.	Paper Title	Author	Year	Related Works	Method Used	Result
1.	Applying Lean-Six-Sigma Methodology in radiotherapy	Pietro Mancosu, Giorgia Nicolini, Giulia Goretti, Fiorenza De Rose, Davide Franceschini, Chiara Ferrari, Giacomo Reggiori, Stefano Tomatis, Marta Scorsetti	2018	Lessons learned by the breast daily repositioning case	DMAIC Six Sigma	LSSM was implemented in a Radiotheraphy department, allowing to redesign the breast repositioning matching procedure
2.	Lean Six Sigma for Intravenous Therapy Optimization: A Hospital Use of Lean Thinking to Improve Occlusion Management	Lee Steere , RN, Marc Rousseau , MBA, Lisa Durland , MS.	2018	Intravenous Therapy Optimization in Hospital	Lean Six Sigma DMAIC	Evaluation of hospital management using Six Sigma to reduce waiting time 69%.
3.	Application of DMAIC Six Sigma Methodology: A Case Study	Pramod Kamble, Dr. Arun Kumar	2017	Manufacturing sector to enhance productivity and quality performance	DMAIC Six Sigma provides a framework	Increase customer satisfaction
4.	Footwear Industry in Bangladesh: Implementation of Six Sigma Methodology	Md Abu Sayid Mia, Md Nur-E-Alam, Farid Ahmad and Kamal Uddin M	2017	Quality control production in footwear industry	DMAIC and DMADV (Verify)	Steps to reduce implementation and maintenance errors
5.	Contribution To The Optimization Of Strategy Of Maintenance By Lean Six Sigma	Ayadi youssouf, Chaib, Rachid,Verzea Ion	2014	Six sigma program in Network Technology Company	Lean Six Sigma	Organizational restructuring to reduce costs

III. GENERAL RESEARCH FRAMEWORK

In general, the research is divided into five major steps namely: Problem ICT Maintenance, DMAIC, Several Decision Making, Hybrid DMAIC after combined with Several Decision Making, and Result. In the first step, the problem of ICT maintenance in a Government court institution will be elaborated and analyzed. Second and Third step, fundamental methods that will be used in this paper will be briefly explained. Pareto and Ishikawa processes are analyzed in this step. The fourth step, this is a main contribution, which is to make a hybrid between six sigma combined with decision-making methods in ICT maintenance. Finally, the performance between the current system in the government court and the proposed method will be compared. All the processes described in Fig.2 below.

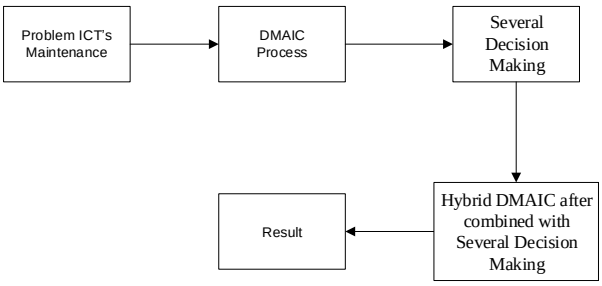

Fig 2. Current Maintenance flow

IV. FUNDAMENTAL METHODS

1 DMAIC Six Sigma

Six Sigma is a method that measures the current system to see its operational effectiveness and efficiency carefully and compared the results with the proposed system [15]. This methodology is often used by companies to improve product quality and operational efficiency. The emphasis is placed on improving business processes, reducing operational and production costs, cutting the redundant business process flow, and measuring the level of customer satisfaction [16]. Six Sigma has two points of view, namely:

- Statistic, measure the standard deviation of the dataset that is processed to get the middle value. There are two types of statistical limits *Upper Specification Limit* (USL) and *Lower Specification Limit* (LSL). A process is said to be defective if the standard deviation is outside the two ranges;
- Methodology, because it's a data-based measurement method that focuses on improving the current business processes, identifying company assets, and reducing company product defects.

In the implementation, six sigma has several main components that are used as business strategies. First, the implementation is focus on evaluating the current business processes of the company. Second, the variables used are data and company facts. Third, the successful implementation of six sigma depends on the support of the company management [17]. Fourth, it takes collaboration from all stakeholders of the company, so the analysis of business process improvement produces quality output. Fifth, the analysis is always sustainable and does not stop at the improvements that have been made. Sixth, the implementation of six sigma has the main objective of prioritizing customer satisfaction [18]. There are five steps to implement DMAIC:

1. Define, collecting current system data on January – June 2018;
2. Measure, establish the basics of improvement from damage;
3. Analyze, isolate the main problem as a focus of improvement (Pareto and Ishikawa diagram);
4. Improve, eliminate the causes of problems to achieve maximum performance (brainstorming and AHP);
5. Control, defend the change that created (compare between old DPMO and new DPMO).

2 Analytical Hierarchy Process (AHP)

AHP can be said a method used to make decisions from several comparisons made based on criteria and several framework choices, so that the decision taken is right [19]. AHP is said to have succeeded in making a decision based on the accuracy of analyzing the system problems that are running based on the trial to the framework created. In this paper, we put AHP in Improve step after analyzing the damage devices which the most occurred in 42 locations. This step will explain how to make a decision based on measure and analyze steps.

V. CASE STUDY

V.1 Proposed ICT Maintenance Flow

The proposed method that we propose to change the flow of ICT maintenance is to shorten the handling of problems that exist in 42 locations. We intend to place engineers in all locations so that when a device breaks, operators in 42 locations can simply contact the engineer in their respective locations.

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This will speed up the handling of problems that occur, reduce the cost of official travel that can arise many times, and reduce the time of service dysfunction. The DMAIC process is a very long because the data collected must be intact covering all the scope of ICT maintenance. Data filtering must also be done as carefully as possible so that the analysis carried out can produce information that becomes a problem that must be given a solution in the improve phase. Another difficult step is when you have to compare the analysis stage with the results of several methods of decision making. The processes are analyzed shown in Fig.3.

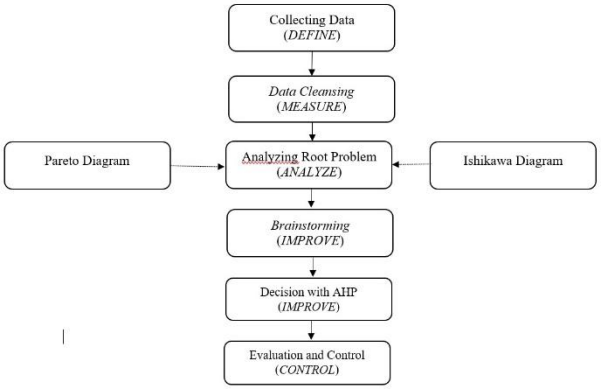

Fig.3. Proposed Maintenance flow.

The above-proposed framework forms a new structured system flow. The process of data collection is divided into the first six months in 2018 and the second six months in 2018. This is done to find out the proposed system changes have a positive impact on the institution. The novelty from Fig.3 is analyzing the weaknesses of the ICT maintenance system using Pareto diagrams and Ishikawa diagrams. Both of these diagrams are usually only used to show the level of disability of a production [20]. There are seventeen devices spread in 42 sites. The hardware devices are grouped as follows:

Table.2. Evaluation Result

Num.	Device Lists	No.	Device Lists
1	Server	10	PC
2	UPS	11	Genset
3	Screen	12	Switch
4	Printer	13	IP Phone
5	Scanner	14	Laptop
6	Infocus	15	Monitor
7	Recorder	16	Router
8	TV	17	Video Conference
9	Speaker		

In Tabel.2, we show all of the devices spread in 42 sites. But, there are 3 sites have one laptop more than others. Thera are Padang, Semarang, and Surakarta.

V.2 Collecting Data with DMAIC Process

Define

In this step, we will explain how to establish quality standards to check devices for ICT maintenance management. This research study started with management meeting to collect what kind of changes which they want it. From the discussion, we can understand that management has difficulty managing ICT maintenance from the 42 locations they have. The obstacles that they can include the absence of clear procedures for what they should do if they encounter damage to the device. But from the discussion, we got information that the leadership of the organization wanted to maintain ICT devices through one hand.

Tabel.3. Total Devices and Damage Devices

Location	2018						Total Damage	Total Devices
	Jan	Feb	Mar	Apr	May	Jun		
Total	70	73	88	68	59	71	429	843

Total device damage between January – June 2018 shown Tabel.3. The table explains the total damage of ICT equipments from each recorded area. This preliminary data is an identification of quality problems carried out as the basis for further analysis. The damage of the equipment that occurs is caused by many things such as the age of the device, lightning disturbances in areas such as Kalimantan, the condition of the untreated server room in several remote areas of the east, insufficient operator knowledge about hardware and device configuration. Therefore identification of device quality problems is needed in the initial stages of analysis.

Measure

Second step is measure that the ICT maintenance management performance based on observed products. In this step we have two actions to do, namely:

1. *Critical to Quality* (CTQ).

This action doing by identify important factors that are the focus of ICT maintenance management.

Tabel.4. Data on Device Inspection Results on ICT Maintenance Management

No.	Devices	Quality Characteristics	Description of defects
1.	Server	Damaged/No	1. Damage 2. BSOD 3. Lamp indicator
2.	UPS	Damaged/No	1. Damage 2. Indicator OFF 3. Low battery
3.	Proyektor	Damaged/No	1. Damage 2. Yellow screen 3. Blurred image
4.	Printer	Damaged/No	1. Damage 2. Replace ink 3. Cartridge problem
5.	Scanner	Damaged/No	1. Damage 2. Defunct
6.	Infocus	Damaged/No	1. Damage
7.	Recorder	Damaged/No	1. Damage
8.	TV	Damaged/No	1. Damage
9.	Speaker	Damaged/No	1. Damage
10.	PC	Damaged/No	1. Damage
11.	Generator Set	Damaged/No	1. Damage 2. Dynamo OFF
12.	Switch	Damaged/No	1. Damage
13.	IP Phone	Damaged/No	1. Damage
14.	Laptop	Damaged/No	1. Damage
15.	Monitor	Damaged/No	1. Damage 2. Broken striped screen
16.	Router	Damaged/No	1. Damage
17.	Video Conference Device	Damaged/No	1. Damage

Data on Tabel.4., the data explains the causes of damage from 17 devices from each location. The data is the majority of the damage that occurred in the area.

2. *Processing Data.*

Control Device Check Map of ICT Maintenance Management.

U control map is used to calculate the number of damage attributes contained in one device, whether the damage is within the control limit or not (Smętkowska & Mrugalska, 2018b).

Tabel.5. Observation Data Overall Check of Devices in 42 locations

Month	Total Damage	Total Devices in 42 Locations	Total Damage per Inspection Unit	LCL	CL	UCL
Januari	70	843	0,083	0,056	0,085	0,114
Februari	73	843	0,087	0,056	0,085	0,114
Maret	88	843	0,104	0,056	0,085	0,114
April	68	843	0,081	0,056	0,085	0,114
Mei	59	843	0,07	0,056	0,085	0,114
Juni	71	843	0,084	0,056	0,085	0,114
Total	**429**	**5058**	**0,509**			
Average	**71,6**	**843**	**0,085**			
$\bar{u}$	**0,085**					

Following map control limits u:

$$\bar{u} = \frac{\sum Total\ Damage}{\sum Total\ Devices} = \frac{429}{5058} = 0.085$$

Example Calculation in January 2018:

$$CL = \bar{u} = 0.085$$

$$LCL = \bar{u} - 3\sqrt{\frac{\bar{u}}{n_i}} = 0.056$$

$$UCL = \bar{u} + 3\sqrt{\frac{\bar{u}}{n_i}} = 0.114$$

Based on the results of calculations in Tabel.5, the value of the number of damage (number of nonconformities) is obtained with the amount of damage per unit of inspection equipment. LCL (Lower Control Limit) and UCL (Upper Control Limit) mean barriers to damage devices. CL (Lower Limit) means the central between LCL and UCL. Between the barriers, the amount of damage per unit when the inspection process is said to be In Control, the opposite is Out of Control. If there is Out of Control data, it means that the problematic unit in that month must be repaired then a re-inspection process will be carried out. The following can be described the results of observation data using u control maps in the Minitab software.

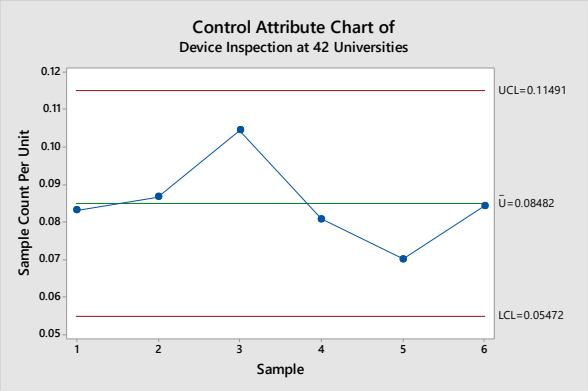

Fig.4. Full Control of Device Check Map at 42 Universities / Locations

Based on the picture shows Fig.4., that the observation data is not out of control. This provides an explanation that the process that occurs has been running well and stable, because the data is within the control limit.

DPMO and Six Sigma Level.

The following are the steps to calculate the Defect Per Million Opportunities (DPMO) value (Mason, Nicolay, & Darzi, 2015) for attribute damage data from an ICT device check:

- **Unit (U) :** The unit is the number of devices carried out examinations from January to June 2018, namely as many as 5,058 devices;
- **Defect (D) :** Defect is the number of defects that occur during the process of checking the device. The number of disabilities that occurred during January to June 2018 was 429 devices;
- **Opportunities (OP) :** Characteristics that are critical for quality that have the potential to become attribute defects are (OP) = 17 (Device Type);
- **Defect Per Opportunities (DPO) :**

$$DPO = \frac{Total\ Damage}{Total\ Number\ of\ Devices\ Checked \times OP} = 0.004989$$

- **Defect Per Million Opportunities (DPMO) :**

$$DPMO = DPO \times 1.000.000 = 4.989$$

Based on the calculation of the DPMO value above, it is known that the inspection of the device reached 50,070 disabilities per one million opportunities. Sigma level calculation is done by converting DPMO to sigma level and adjusting the six sigma conversion table with a 1.5 sigma shift. Next, the conversion of DPMO becomes a sigma level:

$$DPMO = 4{,}08\ sigma$$

Analyze

In Analyze, we know the root of the problem from the cause of the damage that occurred and analyze the repairs needed.

1. *Pareto Diagram.*

This Pareto diagram is a bar graph combined with a line diagram (cumulative number%) which consists of various factors related to a variable arranged according to the magnitude of the impact of these factors in Fig.5.

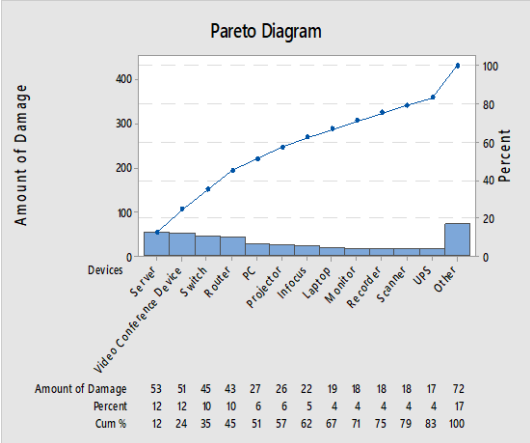

Fig.5. Pareto Diagram shown amount of damage

The Pareto diagram explains that we got four devices which often had trouble. They are server, video conference devices, switch, and router. The four devices greatly affect the quality of service when there is damage or interference. Therefore it must be endeavored as much as possible the damage that occurs to the four devices can be minimized.

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2. *Ishikawa Diagram (Fish Bone).*

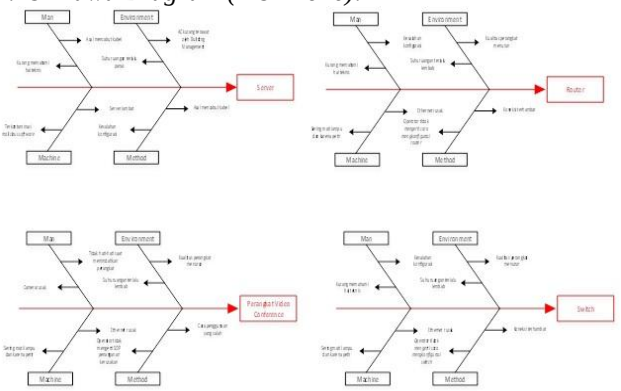

Fig 6. Ishikawa Diagram shown four most damage devices

In Fig.6., we see that the fishbone shown the causes of any specific events. There are four devices which the most damage devices from 17 total devices.

Improve

After knowing the root cause of the problem, a Brainstorming method was conducted with experts from Jakarta (government employees) and person in charge at locations. The method is carried out in the form of discussion to gather opinions, information, and experience from experts.

1. *Brainstorming*.

We held some discussions with management who make any decisions. These are some questions about taking any decision for further:

- What obstacles occur in the presence of a damaged device?
- If there is a damaged device, how long does the PIC location make a report to government employee in Jakarta?
- After making a report, usually how long have our reports been responded to by government employee in Jakarta?
- How long does it take to repair the device?
- If you need to change the device, how long does it take to replace the device?
- According to experts, is the time spent on repairing or replacing the device fast or too long?

Tabel.6. Brainstorming with Management

No	Interviewees	Government Employee	Vendor
1	Director of ICT		✓
2	Head of Infrastructure, Network, and Communications		✓
3	Head of Information System and Data Services		✓
4	Infrastructure Coordinator		✓
5	Information System Coordinator		✓
6	Network Security Coordinator	✓	
7	Data Scientist Coordinator	✓	

The result of interviews generates that the majority of management takes a vendor to maintain all of the devices in 42 locations. The result shown in Tabel.6.

2. *Analytical Hierarchy Process (AHP).*

From the results of brainstorming with experts, there were 2 suggestions, namely replacement or repair or inspection of the device at 42 locations conducted by the vendor or government employee from Jakarta. After getting 2 alternative suggestions, a decision-making method is carried out by making pairwise comparisons between choice criteria and paired comparisons between the choices available. The problem of decision making with AHP is generally composed of criteria and alternatives (T. Costa, Silva, & Pinto Ferreira, 2017). At these steps, we will analyze the three vendors that we get which vendors are most capable of supporting device maintenance in 42 locations. Next the hierarchy:

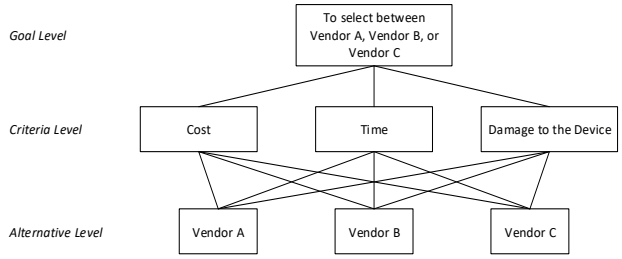

Fig.7. Hierarchy of AHP.

In Fig.7., we can see a hierarchy based on three criteria levels, namely cost, time, and damage to the device. The alternative level which we made such as choosing vendor or engineer from Jakarta.

Furthermore, with Pairwise Comparison (Pairwise Comparison), the following is a description of the level of importance expressed:

1. Equal;
2. Moderate;
3. Strong;
4. Very Strong;
5. Extreme.

Step 1. Square the Pairing Matrix (Criteria)

Pairwise Comparison	Cost	Time	Damage to the Device
Cost	1/1	1/4	1/3
Time	4/1	1/1	3/1
Damage to the Device	3/1	1/3	1/1

→

Pairwise Comparison	Cost	Time	Damage to the Device
Cost	1.00	0.25	0.33
Time	4.00	1.00	3.00
Damage to the Device	3.00	0.33	1.00

$$\begin{bmatrix} 1 & 0.25 & 0.33 \\ 4 & 1 & 3 \\ 3 & 0.33 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0.25 & 0.33 \\ 4 & 1 & 3 \\ 3 & 0.33 & 1 \end{bmatrix} = \begin{bmatrix} 3 & 0.61 & 1.42 \\ 17 & 3 & 7.33 \\ 7.33 & 1.42 & 3 \end{bmatrix}$$

Pairwise Comparison	Cost	Time	Damage to the Device
Cost	3.00	0.61	1.42
Time	17.00	3.00	7.33
Damage to the Device	7.33	1.42	3.00

Step 2. Calculate Eigenvector (Criteria)

	Cost	Time	Damage to the Device	Amount of Row
Cost	3.00	0.61	1.42	**5.03**
Time	17.00	3.00	7.33	**27.33**
Damage to the Device	7.33	1.42	3.00	**11.75**
			∑	**44.11**

Then the Eigenvector on the Normalized Criteria Level is as follows:

	Normalize
Cost	0.113979849
Time	0.619647355
Damage to the Device	0.266372796

Step 3. Trees Weight at Level Criteria

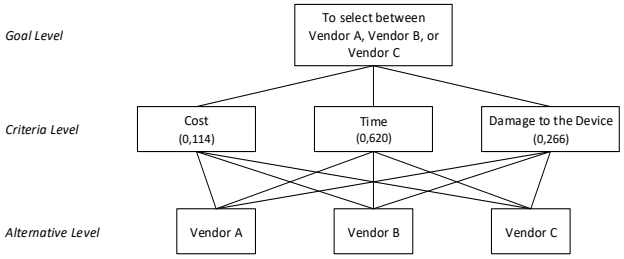

Fig.8. Weight Hierarchy of AHP.

Based on the value of the Eigenvector in Fig.8., it is concluded that:

- Time criteria are the most important first rank;
- Damage to the Device criteria is the second most important rating;
- Cost criteria are the third most important ranking.

Next, the alternative level will be weighted using Pairwise Comparison (Paired Matrix) to the respective criteria. Next is the paired matrix.

Step 4. Square the Pairing Matrix (Alternative)

Cost

Pairwise Comparison	Vendor A	Vendor B	Vendor C
Vendor A	3.00	3.00	6.00
Vendor B	3.00	3.00	6.00
Vendor C	1.50	1.50	3.00

Time

Pairwise Comparison	Vendor A	Vendor B	Vendor C
Vendor A	3.00	1.17	5.33
Vendor B	8.00	3.00	14.00
Vendor C	1.75	0.67	3.00

Damage to the Device

Pairwise Comparison	Vendor A	Vendor B	Vendor C
Vendor A	3.00	1.66	5.50
Vendor B	5.50	2.99	10.00
Vendor C	1.66	0.91	2.99

In the final steps AHP results will be obtained as follows:

Tree Weight Level Alternative to Level Criteria

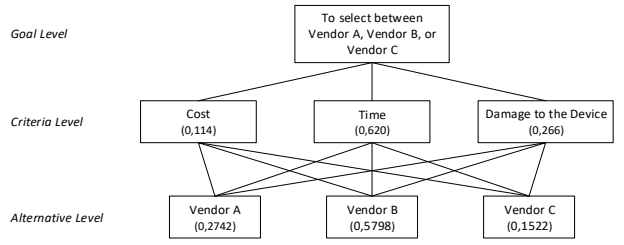

Fig.9. The result of AHP choosing Vendor B

Based on the value of the Eigenvector on Fig.9., it can be decided that:

- Alternative Vendors are the first most important ranking of the three criteria;
- Alternative Engineer from Jakarta is the second most important ranking of the three criteria.

So the best choice for this decision-making case is to use Vendors B to repair/inspection/replacement of devices at 42 locations.

VI. RESULT AND DISCUSSION

A. *Quality Improvement Action Plan.*

In the Improve Phase, action plans are established to carry out the improvement of the quality of Six Sigma. The plan to improve the quality of inspection of devices in ICT maintenance management is as follows in Tabel.7.:

Tabel.7. Plan for Repair of Device Checks in ICT Maintenance Management

Devices	Potential Problem	Cause	Action
Server	Damage	Use with high mobility	Periodic Maintenance
	Lack of Maintenance	Distance is not affordable for maintenance and spare parts delivery	Partnership with Vendors who have representatives in the region
Switch	Damage	*PoE+ port* susceptible to problems when there is shorting and sudden power outages.	Partnership with Vendors who have representatives in the region
	Lack of Maintenance	Distance is not affordable for maintenance and spare parts delivery	Periodic Maintenance
Router	Damage	Sudden and majority events are caused by lightning strikes (Kalimantan and Sulawesi regions) even though a stabilizer has been tried	Partnership with Vendors who have representatives in the region
	Lack of Maintenance	Distance is not affordable for maintenance and spare parts delivery	Periodic Maintenance
Video Conference Devices	Damage	Ethernet and HDMI in-out modules are susceptible to damage, especially in areas prone to dead lights and lots of lightning (Borneo)	Provide a stabilizer and UPS that are guaranteed for 1 year for periodic support when damage occurs.

B. Control.

Control in the DMAIC cycle is the stage where a control mechanism is made and documents all inspection activities for quality improvement. The proposed system has been running well in place of the previous system. The success of the framework must always be controlled to ensure the new system produces the best quality of service at all times (de Freitas, Costa, & Ferraz, 2017). This step explained in Tabel.8 as follows:

Tabel.8. Action Plan and Device Check Quality Improvement Control Tool.

Devices	Action Plan	Control
Server	Periodic Maintenance	Requesting vendor for periodic maintenance
	Partnership with Vendors who have representatives in the region	Annual Contract
Switch	Periodic Maintenance	Requesting vendor for periodic maintenance
	Partnership with Vendors who have representatives in the region	Annual Contract
Router	Periodic Maintenance	Requesting vendor for periodic maintenance
	Partnership with Vendors who have representatives in the region	Annual Contract
Perangkat Video Conference	Periodic Maintenance	Requesting vendor for periodic maintenance
	Partnership with Vendors who have representatives in the region	Annual Contract

The condition of the level of damage to the device at the time before and after setting the performance target using the Six Sigma method in the process of checking ICT devices in Tabel.9., as follows:

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Tabel.9. Observation Data Results Overall Device Checks at 42 locations.

Bulan	Jumlah Kerusakan	Jumlah Perangkat di 42 Universitas	Jumlah Kerusakan per Unit Inspeksi	LCL	CL	UCL
Juli	0	843	0	-0,002	0,001	0,004
Agustus	1	843	0,001	-0,002	0,001	0,004
September	0	843	0	-0,002	0,001	0,004
Oktober	1	843	0,001	-0,002	0,001	0,004
November	0	843	0	-0,002	0,001	0,004
Desember	1	843	0,001	-0,002	0,001	0,004
Total	**3**	**5058**	**0,003**			
Average	**0,5**	**843**	**0,0005**			
$\bar{u}$	**0,001**					

Following map control limits u:

$$\bar{u} = \frac{\sum Total\ Damage}{\sum Total\ Devices} = 0.001$$

Example of Calculation in June 2018:

$$CL = \bar{u} = 0.001$$

$$LCL = \bar{u} - 3\sqrt{\frac{\bar{u}}{n_i}} = 0$$

$$UCL = \bar{u} + 3\sqrt{\frac{\bar{u}}{n_i}} = 0.004$$

Based on the results of calculations, the value of the number of damage (number of nonconformities) is obtained with the amount of damage per unit of inspection equipment. The following can be described the results of observation data using u control maps in the Minitab software in Fig.10.

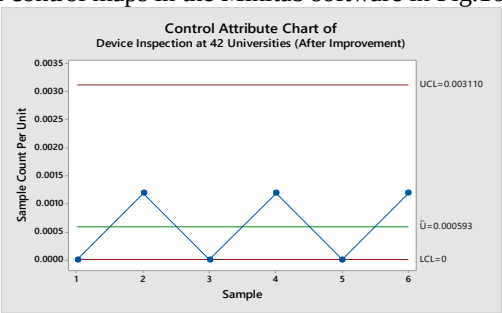

Fig.10. Full Map of Examination of Devices in 42 Locations After Repair.

Based on the picture shows that the observation data is not out of control. This provides an explanation that the process that occurs has been running well and stable, because the data is within the control limit.

C. *DPMO and Six Sigma Level.*

The following are the steps to calculate the Defect Per Million Opportunities (DPMO) value for attribute damage data from an ICT device check:

- **Unit (U):** The unit is the number of devices that were inspected in July to December 2018, namely as many as 5,058 devices.
- **Defect (D):** Defect is the number of defects that occur during the process of checking the device. The number of disabilities that occurred from July to July 2018 was 221 devices.
- **Opportunities (OP):** Critical characteristics of potential quality to be attribute defects are (OP) = 17 (Device Type).
- **Defect Per Unit (DPU) :**

$$DPU = \frac{Total\ Damage}{Total\ Devices} = 0.0006$$

- **Defect per Opportunities (DPO):**

$$DPO = \frac{Total\ Damage}{Total\ Devices\ Checked \times OP} = 0.000035$$

- **Defect per Million Opportunities (DPMO):**

$$DPMO = DPO \times 1.000.000 = 35$$

Based on the calculation of the DPMO value above, it is known that the inspection of the device reached 35 disabilities per one million opportunities. Sigma level calculation is done by converting DPMO to sigma level and adjusting the six sigma conversion table with a 1,5 sigma shift. Next, the conversion of DPMO becomes a sigma level. It shown in Fig.11.

$$DPMO = 5{,}48\ sigma$$

	Before	After
DPMO	4989	35
Sigma Level	4,08	5,48

Fig.11. Results of Application of the Six Sigma Method.

VII. CONCLUSION

From the overall results of the DMAIC six sigma analysis, we can conclude several things. First, support for maintenance services must get approval from management to ensure that all maintenance can run well and according to purpose. Second, to implement change management in this organization, we need some discussions with management or brainstorming to strengthen decision making. Third, Six sigma is combined with several decision-making methods to minimize technical disturbances in the ICT device to the right selection of vendors to carry out the ICT maintenance. The proposed method that we did to optimize maintenance services using a hybrid DMAIC six sigma which then improved the quality of analysis using brainstorming and decision making on the best vendors using AHP. The hybrid of six sigma is very instrumental in reducing the weakness of six sigma which forces the process of monitoring diligently and continuously. Fourth, the hybrid of six sigma which we analyzed using Pareto and Ishikawa diagrams, decision using brainstorming and AHP showed a significant increase in the value of DPMO six sigma from 4,08 level to 5,48 level.

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