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STUDY OF MAINTENANCE OF UPS EQUIPMENT (UNINTERUPTABLE POWER SUPPLY) WITH FAULT TREE ANALYSIS (FTA) METHOD TO PRODUCE TIMELY POWER SUPPLY AVAILABILITY AT SOEKARNO-HATTA AIRPORT

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Abstract *– UPS (Uninteruptable Power Supply) is equipment that supports the availability of a continuous supply of electricity that will work when the main electricity supply from PLN is off and the secondary power supply (Genset) is not ready to take over the electricity supply. The purpose of this study is to determine which equipment components are the cause of potential UPS equipment damage and provide advice on appropriate maintenance actions for the selected system using the Fault Tree Analysis (FTA) method. The study population was 7 units of UPS Benning with a capacity of 100 kVA located in different places at Soekarno-Hatta Airport. The results showed that the frequent damage was due to dead air conditioning which caused the temperature of the battery room to be high.*

Keywords: *Airport, Uninteruptible Power Supply (UPS), Fault Tree Analysis (FTA), proper maintenance*

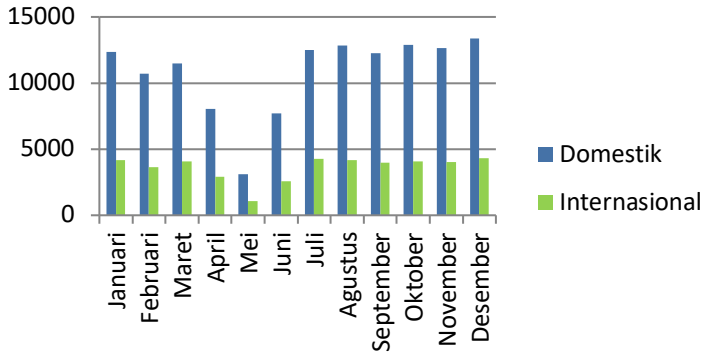
INTRODUCTION

Airport is an area on land and / or waters with certain boundaries which is used as a place for aircraft to land and take off, boarding and disembarking passengers, loading and unloading goods, and places for intra and intermodal transportation of transportation, equipped with aviation safety and security facilities, as well as basic facilities and other supporting facilities as stipulated in Law of the Republic of Indonesia Number 1 of 2009 concerning Aviation item 31 (UU NO. 1, 2009).

In the regulations issued by ICAO Annex 14 Volume I 7th Edition of 2016 Chapter 8 concerning Electrical Systems, it is necessary that the connection of the mains power supply with facilities that have secondary power is required so that the facility is automatically connected to the secondary power supply when the main power supply fails. happen. The time interval between failure of the main resource and restoration of the required service shall be as short as possible, except for related non-precision visual aids, precision approach or runway take-off, the maximum switching time is specified (ICAO, 2018).

As an international airport, Soekarno Hatta Airport not only serves domestic flights but also serves direct flights abroad. The following is Attached Flight Data at Soekarno-Hatta Airport in 2019:

Figure 1 Flight Data of Soekarno-Hatta Interanational Airport

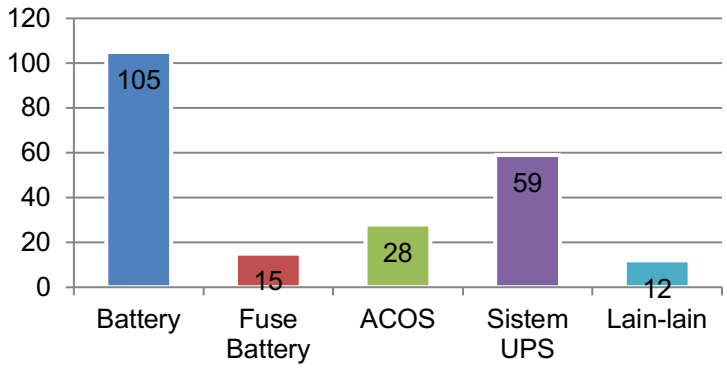


Source: On Time Performance Departure International Flight Detail Report (2019)

One of the equipment that supports the availability of continuous electricity supply is the UPS (Uninteruptable Power Supply) equipment which will work when the main power supply fails and the secondary power supply (Generator Set) is not ready to take over the supply of electricity. This equipment is crucial if it is damaged and does not work in the system so that the electricity supply will be discontinuous or go out waiting for the generator to take over its role.

Good equipment performance can support the creation of safety, security and aviation services. With compliance in the provision of electrical facilities on the ground, the principles of Safety, Security, Service & Compliance (3S + 1C) can be realized. The technical side plays a major role in contributing to the achievement of aviation safety and security. The following is data on damage to UPS Soekarno Hatta Airport equipment in 2019:

Figure 2 Amount of Damage by Type of Equipment



Source: UPS Unit Damage Data Report (2019)

Table 1 UPS Battery Damage Data for 2019

No	Equipment Group	Type of Damage	Quantity
1	Rectifier	Electronic Components are on fire	5
		Over Voltage	5
2	Battery	Under Voltage	10
		Over Temperature	25
		Product Defect	7
3	Battery Connection Cable	Loose Connection	5

Source: UPS Unit failure report (2019)

With the above problems, it is necessary to have a solution through the selection of appropriate maintenance measures for the selected equipment components, in this study the authors used the Fault Tree Analysis (FTA) method. FTA has advantages over other methods because it is able to analyze the potential causes of damage to a system or subsystem.

LITERATURE REVIEW

Maintenance Management

Maintenance is an activity to maintain or maintain factory facilities / equipment and make necessary repairs or adjustments / replacements so that there is a satisfactory production operating state as planned (Danang, 2018).

Some of the benefits that are obtained by implementing maintenance as a support for the company's strategy, namely:

1) Reduced total maintenance costs (spare parts costs and overtime costs)
2) Has better process stability
3) Extend the life of equipment and machines
4) Optimizing the number of spare parts
5) Improve employee / operator safety
6) Reducing damage to the surrounding environment (Bagus Susilo 2017).

Fault Tree Analysis

Fault Tree Analysis describes the state of the system components (base events) and the relationship between base events and top events. Graphic symbols used to represent relationships are called logic gates. The output of a logic gate is determined by the events that enter the gate. An FTA is generally carried out in stages, namely:

1) defines system boundary problems and conditions,
2) Fault Tree Analysis construction,
3) identifying minimum cuts.

Uninteruptible Power Supply (UPS)

Basically the Uninteruptible Power Supply (UPS) is a temporary alternative power source that replaces the main electricity supply, in this case the PLN electricity source. As an electronic device whose main function is to provide backup or additional electricity to certain parts such as computers, data centers, or other parts that are important to get continuous electricity intake for a certain time, a UPS is also known as a backup battery. UPS system that stands alone to the PLN electricity supply system. UPS is expected to be able to protect critical electrical equipment against power supply interruptions (Himawan, 2016)

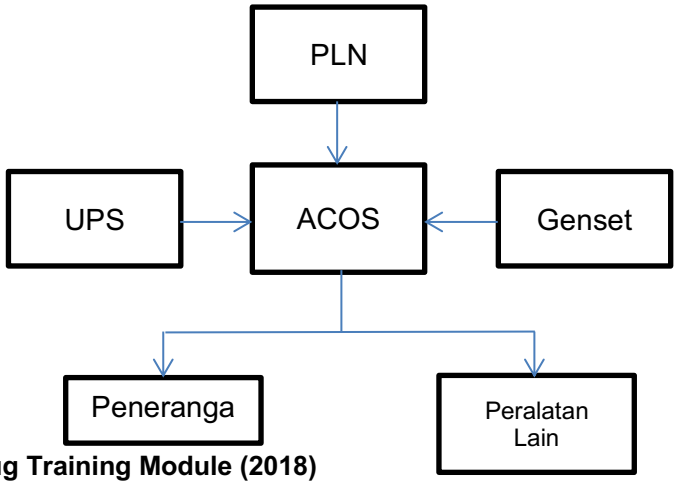
The most important part of the UPS: The essential parts of the UPS are composed of 3 parts. Each part has supporting elements which function almost the same. Namely: (Sunarko, Achmad. 2018)

1) Rectifier-Charger
2) Inverter
3) Battery
4) Transfer switch

Basically, UPS can only work when there is a power failure because using a UPS is a backup of PLN electricity when there is a power cut so that electronic equipment does not experience damage due to not getting electrical power. UPS batteries can generally last up to 15 minutes so there is ample time to safely shut down electronic equipment.

The existence of a Generator Set / Genset which is usually available for backup power cannot immediately take over the electricity supply because it takes time for the generator engine to work which is called running time. This is where the difference between backup power by using a UPS using a generator, otherwise UPS can take over the PLN supply quickly, generally it only takes 4 ms for the UPS to turn on the inverter and take over the PLN supply.

Figure 3 Single Line Diagram of Back Up Electrical Power using UPS and Genset



Source: STPI Curug Training Module (2018)

METHOD

Based on the problems studied, the method used in this research is descriptive quantitative. In this study, the authors conducted research on the study of UPS equipment maintenance at Soekarno-Hatta International Airport, ensuring the performance of the equipment functioning optimally, and

identifying the problem of damage with the Fault Tree Analysis (FTA) method.

Data regarding equipment data, maintenance data, and damage data are analyzed so that the proper maintenance pattern is obtained so that the purpose of maintenance management is effective and efficient.

RESULTS

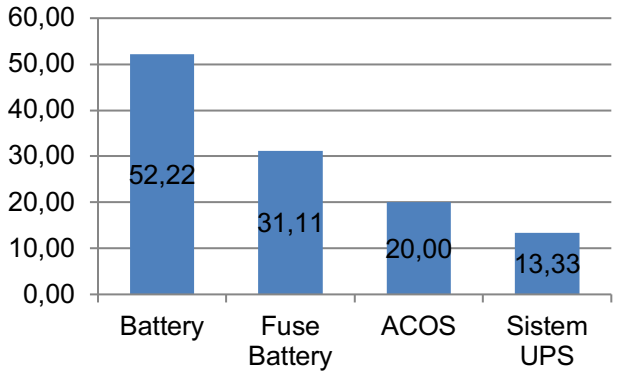
The first stage of the research is to create a Check Sheet table that contains data on damage to UPS equipment in 2019 so that components that are often damaged, factors that cause defects, and the frequency of damage to the UPS Benning 80 kVA can be found. The following is a Check Sheet Defect table based on the frequency of occurrence.

Table 2 Sheet of Examination for Causes of Disabilities as of January 1 to December 31 2019

No	*Subject*	*Defect*	*Frequence*
1	Baterai	Salah Pengoperasian	10
		Tidak dilakukan pengecekan per unit	15
		Pendingin ruangan mati	22
2	Fuse Baterai	Umur Fuse habis	6
		Over Current/arus lebih	7
3	ACOS *(Automatic Change Over Switch)*	Pembersihan tidak optimal	8
		Kondisi lingkungan kotor	10
4	Sistem UPS	Kerusakan modul	6
		Lisensi Produk membatasi kontrol perangkat	6
Total Defect			**90**

Source: UPS Equipment Damage Data in 2019

Figure 4 Benning 80KVA Defect UPS Frequency Graph (2019)



Source: UPS Equipment Damage Data in 2019

All of these processes will be described in the form of a fault tree root diagram of the FTA (Fault Tree Analysis) so that later the root cause of the problem can be found and the probability of each root cause of the problem.

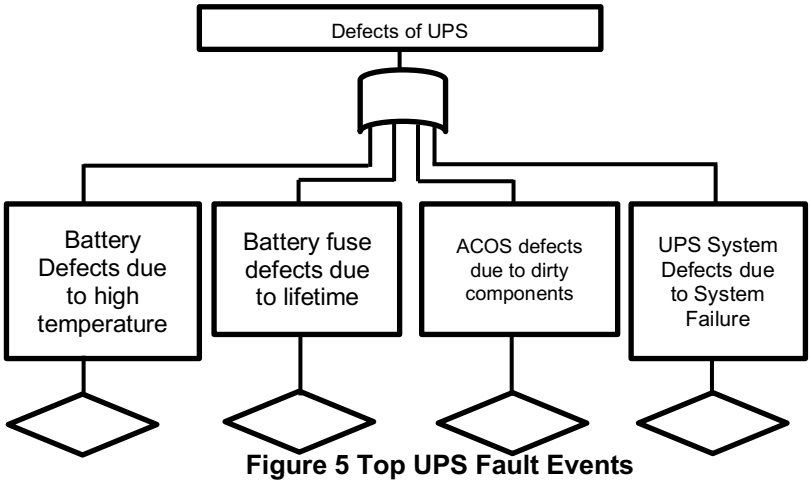


Figure 5 Top UPS Fault Events
Source: Author (2019)

After obtaining the top event or the main cause of defects in UPS equipment, it can be translated back to intermediate events or directly to the basic events obtained from literature studies and observations on conditions in the field. Following are the intermediate events on the UPS device:

1) Battery Defects due to High Battery Temperature

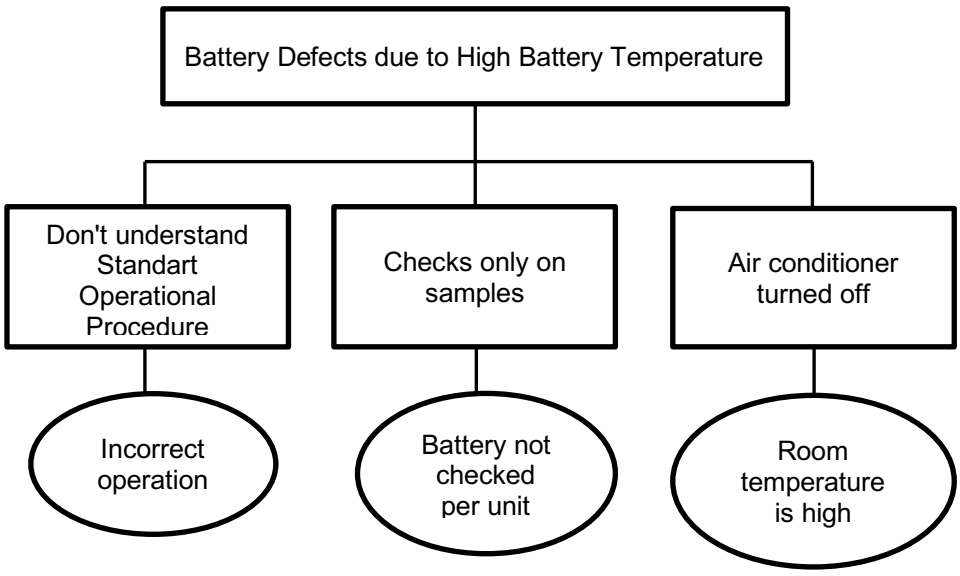


Figure 6 Fault Tree Analysis of Battery Defects
Source: Author (2019)

Table 3 Cumulative Defects of battery due to High temperature

No	Type of factor Cause	Total Occurences As of 1 jan s/d 31 des 2019
1	Incorrect operation	10
2	Battery not Checked per unit	15
3	Room temperature is high	22
Total Occurences		**47**

Source: Author (2019)

2) Defect of Battery Fuse

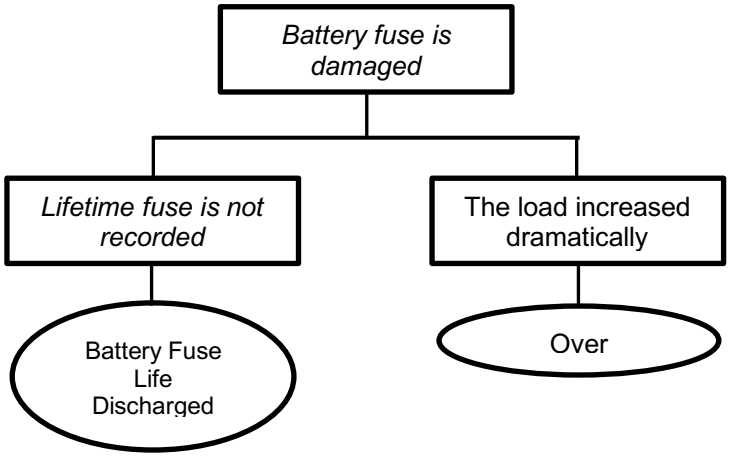


Figure 7 Analysis of Battery Fuse Defective Fault Tree
Source: Author (2019)

Table 4 Cumulative Faulty battery fuse defects

No	Type of factor Cause	Total Occurences As of 1 jan s/d 31 des 2019
1	Battery Fuse Life Discharged	6
2	Over Current	7
Total kejadian		13

Source: Author (2019)

3) Automatic Change Over Switch (ACOS) Defects due to Dirty Components

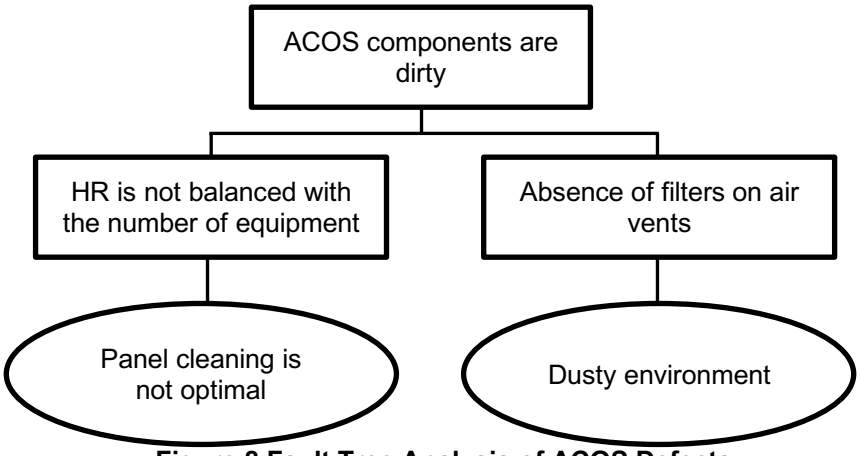


Figure 8 Fault Tree Analysis of ACOS Defects
Source: Author (2019)

Table 5 Cumulative factors causing dirty ACOS components

No	Type of factor Cause	Total Occurences As of 1 jan s/d 31 des 2019
1	Panel cleaning is not optimal	8
2	Dusty environment	10

Total Occurences	**18**

Source: Author (2019)

4) Kecacatan Sistem UPS akibat *System failure*

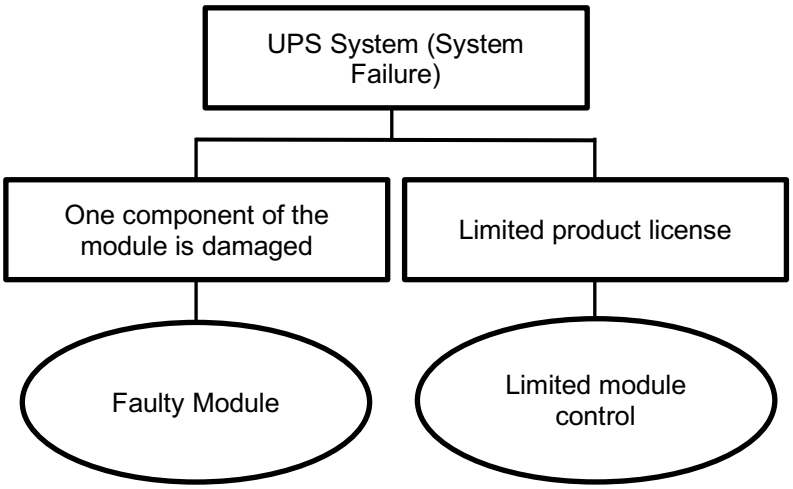


Figure 9 Fault Tree Analysis of UPS System Defects
Source: Author (2019)

Table 6 Cumulative factors causing UPS System due to System failure

No	Type of factor Cause	Total Occurences As of 1 jan s/d 31 des 2019
1	Faulty Module	6
2	Limited module control	6
Total Occurences		**12**

Source: Author (2019)

From the cumulative data on the causes of failure, it can be seen the probability of each disability in each subject. Probability is calculated using the equation for the frequency of defects in each subject divided by the total number of defects.

Table 7 Calculation of Probability Cause of Defects

No	Types of Causative Factors	Total Occurences (1 Jan s/d 31 Des 2019)	Probability
1	Incorrect Operation	10	0,111
2	Battery not checked per unit	15	0,167
3	Air conditioner turned off	22	0,244
4	battery fuse exhausted	6	0,067
5	Over Current	7	0,078
6	Panel cleaning is not optimal	8	0,089
7	Dusty Environmental Conditions	10	0,111
8	Module malfunction	6	0,067
9	Limited module control	6	0,067
	Total Occurences	**90**	

Source: Author (2019)

Minimal Cut Set

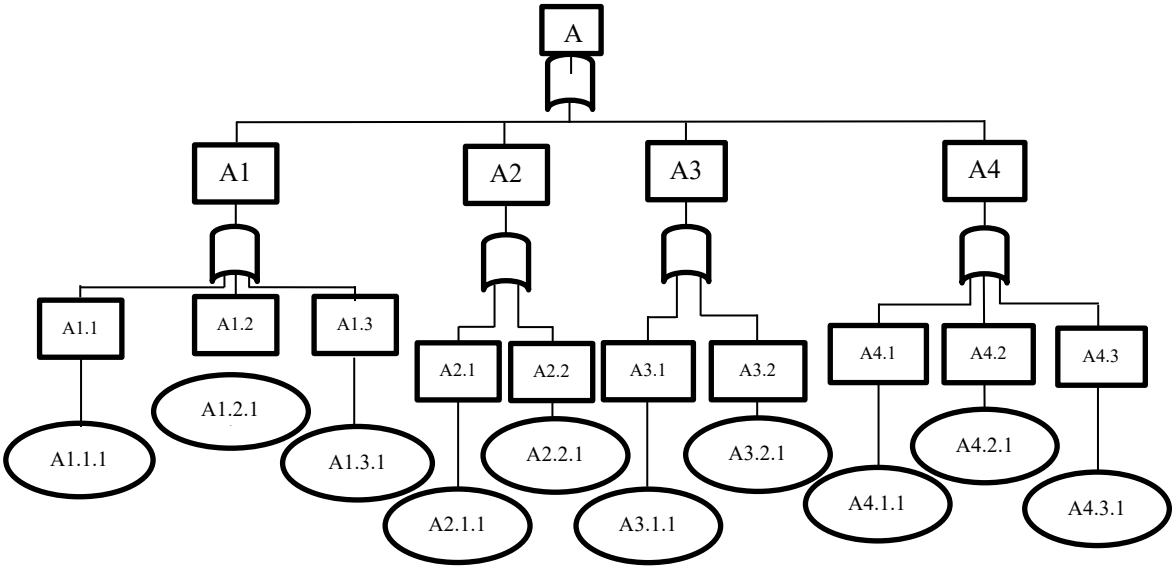


Figure 10 UPS Equipment Fault Tree Chart
Source: Author (2019)

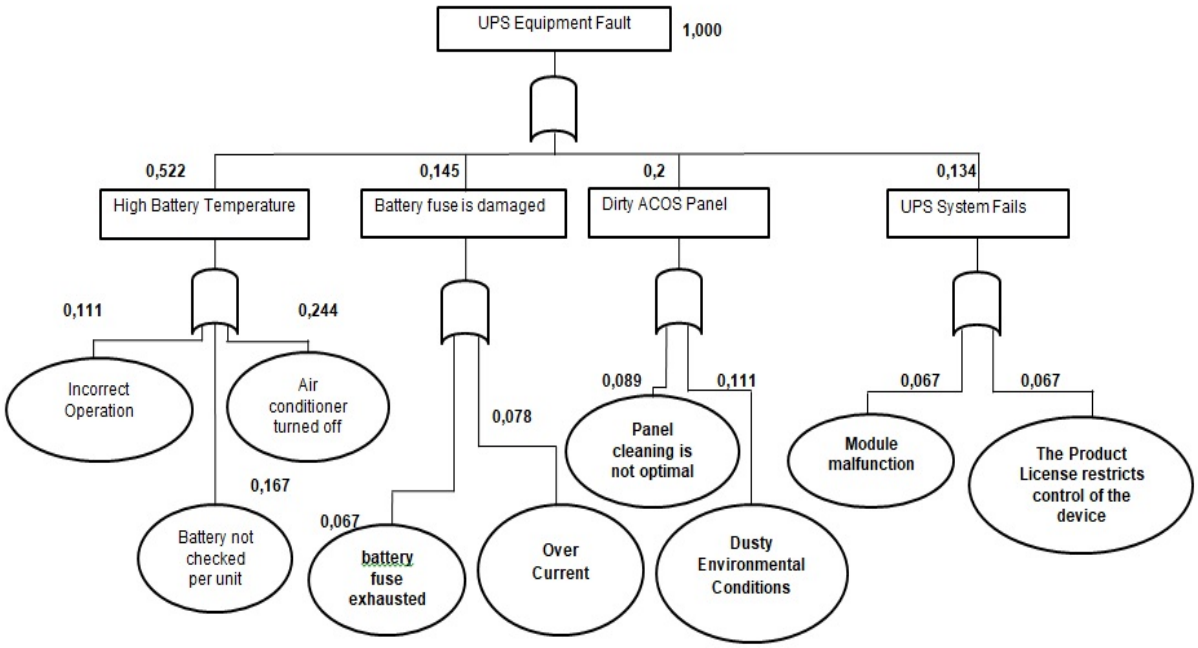


Figure 11 Fault Tree Analysis of UPS Equipment Fault Chart and Probability Value
Source: Author (2019)

CONCLUSION AND DISCUSSION

CONCLUSION

1) The cause of damage to the UPS (UnInteruptible Power Supply) equipment starting from the highest to the lowest, namely the air conditioner is dead which results in a high battery temperature having a probability value of 0.244 or 24.4%, there is no checking per battery unit during procurement items that have a probability value of 0.167 or 16.7%, wrong operation or wrong in carrying out maintenance on the battery which has a probability value of 0.111 or 11.1%, dusty environmental conditions cause the device to get dirty easily has a probability value of 0.111 or 11.1 %, Non-optimal panel cleaning causes dirty components so that they don't work properly has a probability value of 0.089 or 8.9%, Overcurrent occurs so that the battery fuse breaks has a probability value of 0.078 or 7.8%, battery life is exhausted so that the decreased performance has a probability value of 0.067 a tau 6.7%, the occurrence of module damage causes the device to malfunction has a probability value of 0.067 or 6.67%, a product license that is not granted by the device provider company causes technicians to have limited control having a probability value of 0.067 or 6.7%.
2) The maintenance task / maintenance action required is that every maintenance activity of the equipment SOP book must be understood correctly before taking any corrective action, checks must be carried out on all battery units because each unit is a unit that affects battery performance, special monitoring is needed to monitor the state of the equipment temperature , it needs to be included in periodic checks regarding the battery fuse, there is a need for overcurrent protection to protect the battery fuse from being damaged quickly, it is necessary to use a vacuum cleaner so that fine dust is also lifted, it is necessary to add a dust filter to the ventilation holes so as to reduce the incoming dirty air, it is necessary re-cooperation with the vendor for quick module repairs, it is necessary to re-cooperate with the vendor to have more access to device execution in case of trouble.

SUGGESTION

From the results of research conducted at PT Angkasa Pura II (Persero), especially in the UPS & Converter unit regarding the causes of damage and maintenance actions on UPS devices, the following suggestions are obtained from the author:

1) The root cause of the problem which has a high probability can be used as justification for a faster repair in order to minimize damage to the UPS equipment.
2) There is a need for further coordination between routine maintenance implementers and the UPS equipment vendor team to make better steps to overcome limited access to the system due to product licensing.

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