

Preventive Maintenance Implementation in Aircraft Maintenance Organization: A Survey of Maintenance Characteristics of Airbus A320 Maintenance

Zahrina Zihni, Rangga Damar Bagaskara and Yoga Satria

Industrial Engineering Department, Faculty of Engineering

Universitas Indonesia

Depok, 16424, Indonesia

zahrina.zihni@ui.ac.id, rangga.damar@ui.ac.id, yoga.satria12@ui.ac.id

Abstract

Airplane is one of the transportation modes that is safety sensitive and must comply with certain regulations to still be airworthy to fly. Therefore, maintenance plays an important role in the airline industry. To deliver excellent service, airlines need to provide airworthy aircrafts that can perform maximum flight hours to optimize the company's ticket sales. Aircraft Maintenance Organization, under the qualification of Directorate General of Civil Aviation (DGCA) and in accordance with the airline's maintenance manuals, performs and ensures the airworthiness of each aircraft through preventive maintenance activities or better known as maintenance program. Preventive maintenance has several characteristics defining it, including manpower, intervals, spares and materials, managers, failures, etc. The aim of this study is to identify the characteristics implemented in aircraft maintenance organizations in Indonesia which conducted maintenance of Airbus A320 fleet and the importance each characteristic plays in it.

Keywords

Preventive Maintenance, Aircraft Maintenance Organization, Maintenance Characteristics and Maintenance Survey.

1. Introduction

Air transportation is one of the common choices for people to travel domestically and abroad, airplanes can answer people's needs for transportation that can travel long distances in a short time. In the aviation industry, safety is the most important thing in this business (IATA 2022). There should be no room for errors that could potentially compromise the safety of the passengers. Airplanes are expected to be able to fly for a long period of time and have a long life span (Mirza, 2008). To be able to achieve this, it is necessary to carry out preventive maintenance in the aviation industry. In order to fly, an aircraft must have a history of maintenance and pass the qualification according to predetermined standards. The more frequent preventive maintenance is carried out, the higher the reliability of an aircraft to be able to operate and carry passengers (Australian Transport Safety Bureau 2007).

Between the time the aircraft is purchased and the time it is out of service, maintenance includes all actions and procedures taken to keep the aircraft in a state that is fit for flying. Continuous operation of the aircraft's systems, parts, and components without any problems is crucial. To guarantee that, a procedure to maintain the component is carried out, which are categorized as proactive and preventive maintenance. Unexpected problems are resolved during unscheduled maintenance, which is a bad circumstance. Plans and timetables can be disrupted by such downtime, which could also result in further financial harm to the organization. It will affect the company's standing and reputation, not to mention the financial burden it causes. It is vital to identify the required maintenance strategy that is to set up a failure that can cause failure in functional matters (Nurcahyo et al. 2017)

Preventive maintenance performed on an airplane aims to ensure that its component parts are more reliable than a predetermined threshold. By doing this, it will be feasible to decrease the number of unplanned maintenance procedures and hence the number of unexpected downtimes. Preventive maintenance must be carried out at predetermined flight time intervals since airplanes are subject to severe safety standards, which results in downtime. This has a direct impact on operational readiness because any downtime limits the possibility of conducting flight operations. As a result, preventative maintenance activities need to be properly planned and scheduled for the entire

fleet of aircraft. According to Nurcahyo et al (2018) a mature maintenance planning capability is able to guide the organization to achieve excellence in maintenance planning process. Due to multiple restrictions (operating demand, maintenance resources, facilities, locations), uncertainties, and time requirements, the procedure is extremely complex and time-consuming (unpredictable operational assignments, unscheduled maintenance, changing weather conditions), regular adjustments are needed for the flight and maintenance plan. The purpose of this study is to identify the characteristics implemented in the aircraft maintenance organization (AMO), the importance of each function and the correlation between all the functions.

1.1 Objectives

The aim of this study is to identify and analyze the implementation of preventive maintenance characteristics in Indonesian AMOs.

2. Literature Review

2.1 Maintenance

According to the British Standard Institution (1993), maintenance is the combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform a required function. Maintenance is a set of activities, technical, administrative, and managerial carried out during the life cycle of an item, workplace and work equipment so as to maintain the value of an asset (Al-Turki, et al 2014).

2.2 Preventive Maintenance

Preventive Maintenance (PM) is one of the maintenance services to detect, prevent potential damage and extend the life of the equipment (Al-Turki 2014). Preventive Maintenance (PM) includes activities such as repair, cleaning, lubrication, adjustment, and replacement of spare parts (Ben-daya 2009). PM is also used to reduce the unexpected breakdown of an equipment and helps in increasing the service life or lifespan of the equipment. The main objective of Preventive Maintenance (PM) is to minimize the total cost of inspection and repair and equipment downtime. Preventive Maintenance (PM) can be time based or condition based. PM was adopted for emerging technologies because such systems are generally more complex than those based on the use of hand tools. The basic principle of a PM system is to involve predetermined maintenance tasks derived from the function of the machine or equipment and the life of the components. Therefore, tasks are planned to change components before they fail and are scheduled during machine downtime (Basri et al 2017).

2.3 Preventive Maintenance Characteristics

Effective maintenance management always strives to implement maintenance characteristics (Au Yong, 2014). Preventive maintenance has several characteristics that we summarized in Table 1 and based on studying from various literatures.

Table 1. Preventive Maintenance Characteristics

Preventive Maintenance Characteristics	References										
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Labor/Manpower	x	x	x	✓	x	✓	x	✓	✓	x	x
Spare Parts and Material	✓	✓	✓	✓	✓	✓	x	✓	✓	x	x
Maintenance Interval (Schedule)	✓	✓	✓	x	✓	✓	✓	✓	✓	x	x
Failure and Maintenance Downtime	✓	x	✓	x	✓	x	✓	✓	✓	✓	x
Maintenance Data	✓	✓	x	✓	✓	x	✓	✓	x	✓	x
Maintenance Technique, Tools, dan Equipment	✓	x	x	✓	✓	✓	x	✓	x	✓	x
Maintenance Manager (Organization/Policy)	✓	x	✓	x	✓	x	x	✓	✓	x	x
Monitoring and Inspection	x	✓	✓	x	✓	✓	x	✓	x	✓	✓

Preventive Maintenance Characteristics	References										
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Financial Aspects	✓	x	✓	x	✓	✓	✓	x	x	x	x

Notes: P1: Erliza, et al. (2022); P2: Kartiko, et al. (2022); P3: Putra, et al. (2022); P4: Putri, et al. (2022); P5: Salsabila, et al. (2022); P6: Setyoko, et al. (2022); P7: Basri, et al. (2017); P8: Au-Yong, et al. (2014); P9: Chua, et al. (2018); P10: Ahmad, et al. (2012); P11: Horenbeek, et al. (2013); ✓ : considered; X: not considered.

Labor

Allocation and coordination of skilled and knowledgeable labor to establish a maintenance system with good reliability.

Spare Parts and Material

Spare part management involves understanding the specifications of the spare parts itself, which relates to the lifetime of the spare part, the efficiency of the use of spare parts and reordering time, the level of inventory and the placement area used.

Maintenance Interval (Schedule)

Preventive maintenance is carried out at definite time intervals by considering the objectives to be achieved (machine performance, maintenance costs, and others). Planned maintenance intervals are required to reduce the risk of machine failure by estimating specific intervals at which components are expected to fail.

Failure and Maintenance Downtime

Failure may occur in the machine. This failure can be predicted to occur over a period of time based on failure data and its use or is called a failure trend.

Maintenance Data

Maintenance data includes machine health data and failure data. Maintenance data is used to evaluate machine reliability and predict failure.

Maintenance Equipment and Technique

To achieve preventive maintenance performance, equipment and techniques are needed to support activities that are complete and function optimally. So that it is necessary to allocate a budget for the procurement of sufficient tools and equipment, appropriate or sophisticated maintenance equipment is available and the maintenance tools and techniques are fully utilized.

Maintenance Manager (Organization/Policy)

In maintaining the suitability of preventive maintenance, a maintenance manager who has adequate qualifications and experience is required and has a strategic decision-making nature for the organization.

Monitoring and Inspection

Monitoring and inspection are activities intended to observe the actual condition of an equipment as well as routine or periodic inspections to maintain the condition of the equipment.

Financial Aspects

Maintenance is very important to maintain the readiness and availability of the system. However, maintenance costs can put pressure on the company financially. The company should be able to propose an effective maintenance plan to minimize maintenance costs.

3. Methods

An empirical quantitative study was conducted and data were collected using a questionnaire. Seventeen questions were developed based on the characteristics of preventive maintenance in the literature. The questionnaire was compiled based on nine characteristics of preventive maintenance. The nine characteristics of preventive maintenance are determined, such as organization/policy (maintenance manager), maintenance activity and schedule

(interval), labor, spare parts and material, maintenance technique/tools/equipment, maintenance data, monitoring and inspection, and maintenance cost. The list of questionnaires can be seen in Table 2.

Table 2. Questionnaire of Preventive Maintenance Characteristics

No.	Characteristics	List of Questionnaires
1	Maintenance Manager (Organization/Policy)	There is a manual that regulates the procedures for carrying out maintenance on the Airbus A320.
2		Management is involved in the implementation and successful maintenance of the Airbus A320 aircraft.
3	Maintenance Interval (Schedule)	There is a schedule for aircraft maintenance activities in accordance with manufacturer's standards/intervals.
4		Maintenance activities are carried out in accordance with the maintenance schedule that has been prepared.
5	Labor/Manpower	The company has sufficient manpower to carry out maintenance on Airbus A320 aircraft.
6		The company has sufficient manpower qualifications to carry out maintenance on Airbus A320 aircraft.
7		The company pays attention to the validity of the qualifications and the continuity of the manpower to carry out maintenance on the Airbus A320 aircraft.
8	Spare Parts and Material	The company provides sufficient and appropriate spare parts and materials for the maintenance of Airbus A320 aircraft.
9		The company provides spare parts and materials that meet the requirements (conformance in accordance with the provisions of the authority) in the maintenance of Airbus A320 aircraft.
10	Maintenance Technique, Tools, dan Equipment	The company carries out maintenance activities in accordance with applicable procedures or manufacturing manuals (Airbus).
11		The company uses the appropriate maintenance tools in the maintenance activities of the Airbus A320 aircraft.
12		The company can provide sufficient equipment/facilities to support the maintenance of Airbus A320 aircraft.
13	Maintenance Data	The company records/documents all maintenance activities that have been carried out.
14		The company maintains good data storage on the maintenance activities of the Airbus A320 aircraft.
15	Monitoring and Inspection	The company monitors the maintenance and reliability of the Airbus A320 aircraft.
16		The company conducts periodic audits of the conformity of the

No.	Characteristics	List of Questionnaires
		maintenance of the Airbus A320 aircraft with the applicable procedures and manuals.
17	Financial Aspect	The company allocates sufficient funds for the maintenance of the A320 aircraft.

This questionnaire was then used to assess Aircraft Maintenance Organizations (AMO) that conducted maintenance on the Airbus A320 fleet. Three AMOs which qualify under the Directorate General of Civil Aviation (DGCA) was chosen to be the object of this study, which are (1) GMF Aeroasia handles the maintenance of Citilink Indonesia airline, (2) Batam Aero Technic (BAT) handles the Batik Air airline, and (3) AMO under the airline of AirAsia Indonesia. A 5-point Likert-type scale was used, ranging from strongly disagree (1) to strongly agree (5) to assess the implementation of preventive maintenance within the organization.

4. Data Collection

The data was carried out through questionnaires that were sent to employees with more than 5 years experience within the mentioned organizations. This study included three AMOs with a total of 30 respondents which is intended to gather the employees perception of the AMOs preventive maintenance implementation. Those respondents' profiles can be classified as shown in Table 3. Each respondent works for one of the designated AMO, which is shown in Figure 1.

Tabel 3. Respondents Profile

Work Experience	Sum of Respondents	%	Work Area	Sum of Respondents	%	Age	Sum of Respondents	%
5-10 years	10	33%	Operational	13	43%	20 - 30	14	47%
10-15 years	8	27%	Supporting	17	57%	31 - 40	8	27%
16 - 20 years	9	30%				41 - 50	5	17%
> 20 years	3	10%				> 50	3	10%
Total	30			30			30	

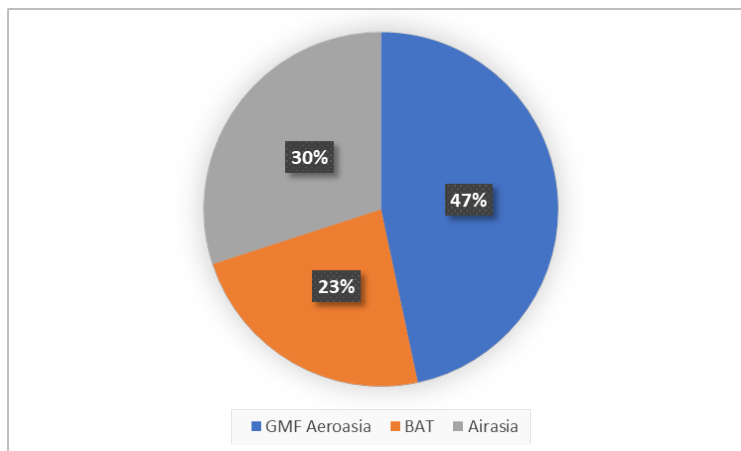


Figure 1. AMO Surveyed

5. Results and Discussion

Based on the questionnaires, the results can be seen in Table 4.

Table 4. Questionnaire Results

No	Preventive Maintenance Characteristics	Respondents					Total Score	Average Score
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
1	Organization dan Policy	0	0	0	18	42	282	4.70
2	Maintenance Activity dan Schedule	0	1	4	19	36	270	4.50
3	Labor/Manpower	0	1	14	40	35	379	4.21
4	Spare Part dan Material	0	3	8	20	29	255	4.25
5	Maintenance Technique, Tools, dan Equipment	0	1	3	28	58	413	4.59
6	Maintenance Data	0	0	3	19	38	275	4.58
7	Monitoring dan Inspection	0	0	2	22	36	274	4.57
8	Financial Aspect	0	3	5	10	12	121	4.32

Based on the Table 4 above, it can be seen that the highest characteristics implemented in AMO's in Indonesia is regarding Organization and Policy or Maintenance Manager. The second most highest implemented characteristic is Maintenance Technique, Tools, and Equipment. The third most highest implemented characteristic is Maintenance Data. The complete ranks of all characteristics are shown in Figure 2.

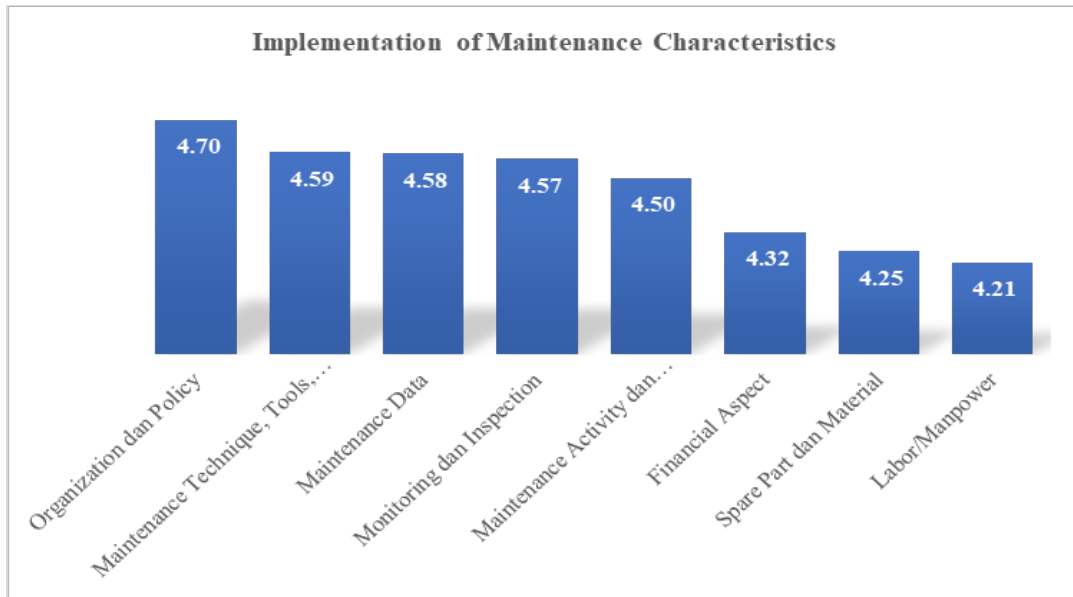


Figure 2. Implementation of Maintenance Characteristics

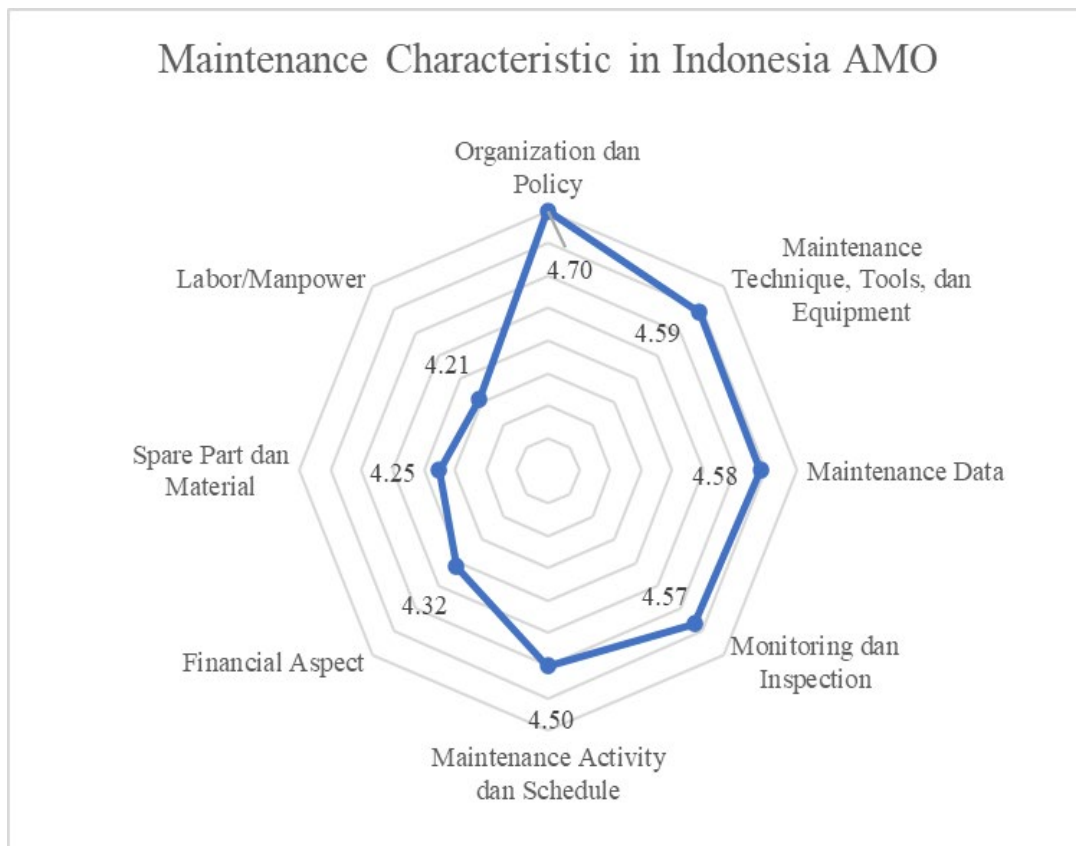


Figura 3. Result of Maintenance Characteristic in Indonesian AMOs

6. Conclusion

This research aimed to identify and analyze the implementation of preventive maintenance characteristics in Indonesian AMOs. Based on above results, it can be concluded that AMOs in Indonesia most effectively implement

the maintenance manager characteristics, which is defined as organizational and policy implementation in the organization itself. This is because the aviation industry is one of the tightest industries to follow the rules, therefore a strict maintenance manager is required to ensure the airworthiness of the aircraft is maintained through the implementation of preventive maintenance.

This research provides theoretical and practical contributions, whereas this research was one of the few attempts to determine preventive maintenance characteristics in the Aircraft Maintenance Organization industry in Indonesia. Practically, this study could guide the organizations to review its implementation on each characteristic by evaluating the effectivity of each activity within the characteristics.

The limitation of this research lies in the lack of data surveys on the distribution of questionnaires and the AMOs that are counted in for. Future research suggested that more respondents could take part in such studies. Furthermore, more AMOs should have been observed to gain a larger view of the preventive maintenance characteristics implementation in this industry.

References

- Ahmad, R., & Kamaruddin, S., An overview of time-based and condition-based maintenance in industrial application. *Computers & Industrial Engineering*, vol. 63, no. 1, pp. 135-149, 2012. doi: 10.1016/j.cie.2012.02.002
- Al-Turki, U. M., Ayar, T., Yilbas, B. S., & Sahin, A. Z., Integrated maintenance planning. In *Integrated Maintenance Planning in Manufacturing Systems*, Springer, Cham, pp. 25-57 2014.
- Australian Transport Safety Bureau., *How Old is Too Old? The impact of ageing aircraft on aviation safety*, Australian Government, Vol. B20050205, 2007.
- Au-Yong, C., Ali, A., & Ahmad, F., Preventive Maintenance Characteristics towards Optimal Maintenance Performance: A Case Study of Office Buildings. *World Journal Of Engineering And Technology*, vol. 02, np. 03, pp. 1-6, 2014. doi: 10.4236/wjet.2014.23b001
- Basri, E., Abdul Razak, I., Ab-Samat, H., & Kamaruddin, S., Preventive maintenance (PM) planning: a review. *Journal Of Quality In Maintenance Engineering*, vol. 23, no. 2, pp. 114-143, 2017. doi: 10.1108/jqme-04-2016-0014
- Ben-Daya, M., Duffuaa, S. O., Raouf, A., Knezevic, J., & Ait-Kadi, D. (Eds.), *Handbook of maintenance management and engineering*, London: Springer, Vol. 7, 2009.
- British Standard Glossary, *Glossary of maintenance management terms in Terotechnology*, 1984. <https://doi.org/10.3403/00122684>
- Chua, S., Zubbir, N., Ali, A., & Au-Yong, C., Maintenance of high-rise residential buildings. *International Journal Of Building Pathology And Adaptation*, vol. 36, no. 2, pp. 137-151, 2018. doi: 10.1108/ijbpa-09-2017-0038
- IATA Aviation safety, IATA. Available at: <https://www.iata.org/en/youandiata/travelers/aviation-safety/> (Accessed: October 18, 2022).
- Mirza, M., Economic Impact of Airplane Turn-Times. *Boeing AeroMagazine*, Article 03(Q04), 2008.
- Nurcahyo, R., Arisaputra, A. E., & Farizal, Development of maintenance program with Markov-simulation method in aviation industry. 2017 4th IEEE International Conference on Engineering Technologies and Applied Sciences (ICETAS), 2017. <https://doi.org/10.1109/icetas.2017.8277888>
- Nurcahyo, R., Darmawan, D., Jannis, Y., Kurniati, A., & Habiburrahman, M., Maintenance planning key process area: Case study at oil gas industry in Indonesia. 2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), 2018. <https://doi.org/10.1109/ieem.2018.8607527>
- Putri, I. A. H., Gita, G. G. R., Dondokambey, N. V., Suryaputri, Z., & Nurcahyo, R., Analysis of Maintenance Management Implementation and Strategy Conceptualization: A Case Study of Hospitals' Maintenance Management in Indonesia. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Turkey. 2022.
- Van Horenbeek, A., Buré, J., Cattrysse, D., Pintelon, L., & Vansteenwegen, P., Joint maintenance and inventory optimization systems: A review. *International Journal Of Production Economics*, vol. 143, no. 2, pp. 499-508, 2013. doi: 10.1016/j.ijpe.2012.04.001

Biographies

Zahrina Zihni, ST is currently a master's degree student in the Industrial Engineering Department at Universitas Indonesia. She holds a Bachelor of Engineering degree in Industrial Engineering from Brawijaya University. Zahrina Zihni currently works as Aircraft Maintenance Planner at Pelita Air.

Rangga Damar Bagaskara, ST is currently a master's degree student in the Industrial Engineering Department at Universitas Indonesia. He holds a Bachelor of Engineering degree in Industrial Engineering from Brawijaya University. Rangga Damar Bagaskara currently works as Assistant Inventory Control and Cataloger Officer at PT Pembangunan Jawa-Bali, a subsidiary of PT PLN (Persero).

Yoga Satria, ST is currently a master's degree student in the Industrial Engineering Department at Universitas Indonesia. He holds a Bachelor of Engineering degree in Industrial Engineering from Universitas Diponegoro. Yoga Satria currently works as a civil servant at Semarang Labor Department.