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Implementation of Safety Risk Management in Aircraft Airfframe Maintenance

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ABSTRACT: This study analyzes the application of Safety Risk Management in the practice of aircraft maintenance at AMTO (Aircraft Maintenance Training Organization) Indonesia Aviation Polytechnic Curug. The research method used is descriptive qualitative. Starting with hazard identification, risk assessment, and continuing with mitigation actions. Risk assessment uses the Risk Matrix. The results showed that 9 hazards were at tolerable levels, namely 4 hazards in the component release phase, 3 hazards in the inspection phase, and 2 hazards in the installation and adjustment phase. Recommended mitigation measures include additional training, safety briefing, safety promotion, supervision of important phases, and periodic checks on tools and equipment. This research is then used as a document for compliance with Safety Risk Management according to the SMS Implementation Plan at the AMTO (Aircraft Maintenance Training Organization) of the Indonesian Aviation Polytechnic Curug.

Keywords: Airframe Maintenance, Hazard Identification, SafetyRisk Management

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INTRODUCTION

The implementation of the Safety Management System is an obligation for all flight operators, both national and international. (ICAO, 2016; ICAO 9859, 2018). The operators in question include Aircraft Operator Certificate (AOC), Approved Maintenance Organizations (Aircraft Maintenance Workshops), Approved Training Organizations (ATO), Airports, Aircraft Manufacturers, and ATS providers. In an effort to fulfill the Safety Management System, each operator has a work program and targets which are divided into several phases and contained in the SMS Implementation Plan. The implementation of safety risk management is mandatory for all flight operators as mentioned above. This research will discuss the implementation of safety risk management in Approved Training Organizations (Gstaettner et al., 2022; Porsanger & Magnussen, 2021; Xiahou et al., 2022).

This research (Saputra et al., 2022) uses a qualitative method to identify hazards in the process of replacing the Boeing 737-300 engine at PT. Mulya Prosperous Technology. The research results show that mitigation is carried out to overcome the hazards found by eliminating or reducing risks to an acceptable level. In the same location, research (Falahudin et al., 2022) discusses the application of Safety Risk Management in the tools store and ground support equipment areas. discusses the application of HIRAM in the tools store area and ground support equipment. This study uses a descriptive qualitative method with the HIRAM analysis tool and the SHELL model to identify potential hazards and risks in the tools store and ground support equipment area at PT Mulya Sejahtera Technology. The results showed that there were 20 potential hazards with 6 high risks, 8 medium high risks, and 6 medium risks. Suggested mitigation measures include the provision of safety facilities, socialization, training, and briefing of operational personnel. Research (Priyangga et al., 2020; Wicaksono et al., 2020) also discusses the application of safety risk management in workshops at AMO PPI Curug. Research (Rivaldi et al., 2022) analyzed the effect of the work environment on safety risk management in aircraft technicians and found a strong influence of work environment factors on safety risk management (Brickel et al., 2013; Chen et al., 2022; Zhang et al., 2021).

These studies are the implementation of Safety Risk Management in Approved Maintenance Organizations (AMO) in Indonesia but there is no research on Safety Risk Management in AMTO (Approved Maintenance Training Organizations) so this research is interesting to study .

AMTO (Approved Maintenance Training Organization) is an institution or organization that is given the authority to carry out certain training, either a basic certificate or a type rating in accordance with the Operation Specifications provided by the Directorate of Airworthiness and Aircraft Operation, Ministry of Transportation. AMTO is also an Approved Training Organization that is required to implement a Safety Management System (Indonesia, 2017).

One of the competencies taught to students in training activities at AMTO is the practice of maintaining aircraft frames at the Airframe Maintenance workshop which is a hands-on practice requirement for the A1 (Airframe Fix Wing) license. In accordance with AC 147-02 (Indonesia, 2017), practicum implementation requires equipment, supplies, and materials according to the required standards. The practice includes the activities of removing, testing, setting the function of components, and reassembling them on the aircraft frame.

The practice implementation process is a hazard because it involves equipment such as aircraft jacks, and cranes and hazardous materials such as paint removal and NDT (Non-Destructive Test) fluids. The risks that arise are potentially dangerous, including for the safety of personnel, aircraft trainers, or the surrounding environment. Good risk management is needed to minimize the above risks to an acceptable level.

Through this research, an analysis of the application of safety risk management at AMTO will be carried out, namely in the practice of maintaining aircraft frames so that risks that arise can be identified and mitigation measures can be applied. The effectiveness of implementing safety risk management is directly proportional to the level of safety and of course, it can maximize productivity (Astrada & Tejamaya, 2021; Fergusan et al., 2020; Nugroho, 2021; Priyangga et al., 2020; Jacob & Phuspa, 2019)

This research is also part of the contribution to fulfilling SMS Implementation in the Safety Risk Management phase according to the SMS Implementation Plan at AMTO. The results of this research will then be stored in the HIRA (Hazard Identification and Risk Assessment) database.

METHOD

This study uses a descriptive qualitative method, namely the process of hazard identification, risk assessment, and mitigation. This series of processes is also one of the proactive methods in the safety management system in accordance with ICAO Annex 19, namely actively identifying safety risks through a series of analyses of activities within an organization. In the process, the flow of risk assessment and control is shown in Figure 1 of the HIRAM (Hazard Identification, Risk Assessment and Mitigation) flow.

Figure 1. HIRAM FLOW

The object of research is the implementation of the Beechcraft Sundowner C23 airframe overhaul practice in the AMTO Airframe Maintenance and Repair Practice course at the Indonesian Aviation Polytechnic Curug. The research location is in Hangar 01 Aircraft Engineering Indonesia Aviation Polytechnic Curug, Jalan Raya PLP Curug, Tangerang Banten. The practice is carried out by D.IV Aircraft Engineering D.IV students/cadets in semester IV.

Method of collecting data

The data collection method was carried out by direct observation of the implementation of frame overhaul practices in accordance with the 2000 Hours Inspection Task Card. The practice phase starts with removal, inspection, installation, repair, or adjustment. The observation was carried out once in a frame overhaul practice cycle using 1 Sundowner C23 aircraft registration number PK-ANQ with a credit load of 6 practice credits.

In addition, through document studies referring to related safety documents, such as the Safety Management Manual, Technical Training Procedure Manual, internal audit results, and safety records in AMTO 147D-03. The data referred to in these documents are data regarding safety, corrective actions, safety reports, and incident history at Hangar 01 Aircraft Engineering.

Data analysis method

Data analysis techniques are carried out by processing the data that has been obtained referring to the Risk Matrix in the Safety Management Manual AMTO 147D-03. (AMTO 147D-03, 2021). Hazard identification is the identification of potential hazards that exist in the entire process of overhauling the aircraft frame, including potential hazards from the use of tools and equipment, understanding of task cards, and environmental factors such as lighting, dust, and others. As well as the practice process itself which relates to standard practices and the use of hazardous materials such as paint remover and Non-Destructive Test (NDT) Dye penetrant and painting materials. Risk Assessment is carried out by determining the probability level (likely to occur) as shown in Table 1. Probability levels start from level 1 to 5.

Table 1. Risk Probability

Definition	Meaning	Value
Frequent	*Likely to occur many times (has occurred frequently)*	5
Occasional	*Likely to occur some times (has occurred infrequently)*	4
Remote	*Unlikely, but possible to occur (has occurredrarely)*	3
Improbable	*Very unlikely to occur (not known occurred)*	2
Extremely Improbable	*Almost inconceivable that event will occur*	1

While determining the level of Severity (worst impact if it occurs) as in Table 2 is denoted by letters A to E. Then the results of the known probability and severity are combined using Figure 2, namely the Risk Matrix to determine the position of the results of the risk assessment. Positioning is divided into 3 based on color, namely red, yellow, and green. Red for intolerable (3A, 4A, 4B, 5A, 5B, 5C) yellow for tolerable (2A, 2B, 2C, 3B, 3C, 3D, 4C, 4D, 4E, 5D, 5E) and green for acceptable (1A, 1B, 1C, 1D, 1E, 2D, 2E, 3E).

Table 2. Risk Severity

Definition	Meaning	Value
Catastrophic	- *Equipment destroyed,* - *Multiple deaths*	A
Hazardous	- *A large reduction in safety margin, physical distress of a workload such that the operatorscannot be reied upon to perform their tasks accurately* - *Serious injury or death to a number of people* - *Major equipment damage.*	B

Major	- *A significant reduction in safety margin, a reduction in the ability of the operators to copewith adverse operation conditions as a result ofan increase in workload, of as a result of conditions impairing their efficiency.* - *Serious incident* - *Injury to persons*	C
Minor	- *Nuisance,* - *Operation limitation,* - *Use of emergency procedure* - *Minor incident*	D
Negligible	- *Little consequences*	E

Figure 2. Matrix Risk

	Catastrophic 'A'	Hazardous 'B'	Major 'C'	Minor 'D'	Negligible 'E'
5 Frequent	5A	5B	5C	5D	5E
4 Occasional	4A	4B	4C	4D	4E
3 Remote	3A	3B	3C	3D	3E
2 Improbable	2A	2B	2C	2D	2E
1 Extremely Improbable	1A	1B	1C	1D	1E

RESULT AND DISCUSSION

Based on the results of the safety risk management analysis, the results are shown in Table 3. The risk assessment process is carried out in three phases of practical work, namely the component removal phase, the inspection phase, and finally the reassembly and adjustment phase. The component release phase is in accordance with the 2000 hours Inspection task card Sundowner C23 identified 4 hazards, namely the first starting with the jacking of the aircraft, which is the process of lifting the aircraft using a jacking device. The three points used for lifting the aircraft are the main landing gear (right and left) and the nose landing gear. This process is high risk because it can cause the hand to be caught, especially with the heavy weight of the aircraft. In addition, errors in lifting procedures can cause damage to the aircraft. So the probability assessment is 2 and severity is B. Existing mitigation, namely supervision from lecturers and suggested mitigation is safety briefing before implementation and checking jacking tools regularly to ensure the mechanism of the tool is safe to use.

The second hazard is the misinterpretation of the Maintenance Manual. When removing components such as removing aircraft seats, carpets, floors, flight controls, and landing gear, refer to the aircraft maintenance manual. There are special procedures and treatments in the release process, especially since this aircraft still uses the numbering system in the numbering system or reading the maintenance manual so it is possible for misunderstandings to occur in the procedure. At present, in general, aircraft maintenance manuals use the ATA Chapter system for indexing and numbering. So the probability assessment is 3 and the severity is C. The suggested mitigation is the pre-test of reading the maintenance manual per group of cadets who will carry out hands-on practice of aircraft frame maintenance. In addition to reading the maintenance manual, it also checks understanding of the maintenance procedures that must be carried out. Supporting courses have been implemented in semester 1 to semester 4.

The third hazard identified was the handling of the component after it was disengaged. Detailed handling, namely the recording of each component including the part number and serial number on the serviceable tag. The next step in component handling is the component storage process.

Storage treatments vary, such as on shelves, staggers, or other storage areas such as tables, and others.

Table 3. Risk Assessment Results

No	*Hazard Identification*	*Consequences*	*Existing Mitigation*	*Existing Risk matrix*	*Mitigation Action*	*Expected Risk Matrix*
Component Release Phase (Equipment, furnishing, landing gear, and flight control)						
1.	Use of an airplanejack	- Pinched hands - Damage to the wings	Supervision from the lecturer	2B	- *Safety briefing before jacking* - *Routine inspection of jacking equipment*	1B
2.	Misinterpretation of the Maintenance Manual	Component removal error	-	3C	*Pre test about MM reading before practice begins*	2D
3.	Component handling	Damage/ missing components	Supervision from the lecturer	3B	Addition of safety promotion	1B
4.	Removing locking wire/cutter pin	- Scratch wound - Leftover pieces can be FOD	Provision of first aid kits	4D	- Preparation of Eye Wash - Supervision during clean up (cleaning) -	2D

Inspection/Testing Phase						
1.	Use of paint remover	Wounds on the hands / skin (blisters)	Wear PPE	4D	Addition of Safety Promotion and training	2D
2.	Using NDT Dye Penetrant	- Wounds / irritation to the skin - Residual red streaks on components	Wear PPE	4D	Addition of Safety Promotion and training	2D
3.	Use of paint materials (paint, thinner, corrosion prevention)	- Wounds / irritation to the skin - Paint mist littered other planes.	Wear PPE	4D	Addition of Safety Promotion and training	2D
Reinstallation and Setup Phase (Installation, adjustment, and setting)						
1.	Improper installation of components	- Functional incompatibility/ - Aircraft damage	Supervision from the Lecturer	3C	Supervision of the installation of important parts	2D
2.	Faulty flight control or landing gear settings	- Functional incompatibility/ - Damage to the plane	Supervision from the Lecturer	3C	Supervision and final check on important parts.	2D

Inappropriate storage can cause damage to the component itself. The probability rating is 3 and the severity is B. The existing mitigation that has been carried out is under the supervision of the lecturer. The suggested mitigation is the addition of safety promotion in practice areas such as posters, recommendations, and pictures which are mainly related to safety and component handling. Apart from that, training/general lectures from experts or practitioners can also be added (May, 2020; Vasconcelos, 2018; Zhou, 2018).

The fourth hazard in this process is the removal of the locking wire or cotter pin. Care is required when removing these components as they can injure your hands. Besides that, the remaining cut wire can also be FOD (Foreign Object Damage) for aircraft. The probability rating is 4 and the severity is D. The suggested mitigation is providing a first aid kit and supervising the clean-up process after the practice.

The inspection or testing phase identified 3 hazards, namely the use of paint remover, NDT Dye Penetrant, and the use of paint materials such as zinc chromate, top coating, and corrosion prevention. Using paint remover is dangerous if it gets in your hands or eyes because the material is hot and can burn your skin. An example of using paint remover is shown in Figure 3. The existing mitigation is to use PPE, namely gloves and goggles, but it can still penetrate the inner skin. The probability assessment is 4 and the severity is D. The suggested mitigation is by adding safety promotion and related training such as through public lectures or sharing sessions.

Figure 3. Use of Paint Remover

The use of NDT Dye Penetrant is carried out to detect cracks in certain components. hazard

that arises has the potential to cause injury or irritation to the skin. In addition, the remaining penetrant can leave marks on the inspected part if it is not cleaned properly and thoroughly. The rest of the color can appear again even though it has been repainted with the color of the plane. The probability rating is 4 and the severity is D. Use Dye penetrant as shown in Figure 4.

The existing mitigation is by using PPE. The suggested mitigation is by adding safety promotion and training. and additional time for drying remaining penetrant and cleaning which must be maximized and monitored.

Figure 4. Use of Dye Penetrant

The use of paint material is almost the same handling. The thing to pay attention to is the painting process. Ideally done in a special room for painting (painting room). Painting in an aircraft hangar where it is mixed with other aircraft has the potential to contaminate other aircraft as a result of flying fog/remaining paint. The suggested mitigation is to add a special barrier or cover for painting the plane so that the painting fog can be localized only in that area.

The final phase is Reinstallation and setup. Mainly the flight control components, namely ailerons, flaps, stabilizer, and rudder, there are mechanisms starting from the control column, flight control cable, pulley, chain, and turnbuckle. There are installation and adjustment procedures for appropriate flight control operations, be it tension or degree (FAA, 2018; United States. Flight Standards Service., 2018; Xie, 2018). Installation errors such as the torsion bolt process. Excess torque can cause the bolt to break and even damage the flight control (Santos & Melicio, 2019.

CONCLUSION

The results of the implementation of Safety Risk Management in the aircraft frame maintenance practice process found 9 hazards. The hazard details are 4 hazards in the component removal process (equipment, furnishing, landing gear, and flight control), 3 hazards in the inspection phase, and 2 hazards in the reassembly and adjustment phase. The results of the risk assessment with the level of probability and severity found that all of them fall into the tolerable category.

Suggested mitigation includes adding safety promotions such as pamphlets, safety recommendations, and posters. additional training or general lectures related to treatment procedures. In addition, the provision of eye wash, periodic checking of jacking equipment, supervision, and final checking by the lecturer for vital parts or phases.

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