HFACS for Mapping Strengthening Human Factor Training Material on Prospective Aircraft Technicians

Mochammad Rifai¹, Achmad Setiyo P², Yuyun Suprapto³, B B Harianto⁴ and Ade Irfansyah⁵

Dept. of Air Navigation, Politeknik Penerbangan Surabaya, Surabaya, Indonesia

Email: m.rifai@poltekbangsby.ac.id¹, achmadsetiyo@poltekbangsby.ac.id², yuyunsuprapto@poltekbangsby.ac.id³, bambangbagusharianto@poltekbangsby.ac.id⁴, ade_irfansyah@poltekbangsby.ac.id⁵

Abstract. In order to reduce the number of flight accidents due to human factors, the ICAO issued Standards and Recommended Practices which were followed up by the Indonesian government by issuing regulations regarding the need to attend human factor training for technician personnel. One method that can be used to analyse flight accidents related to human factors is the Human Factors Analysis and Classification System (HFACS). HFACS analysis will be able to provide information about the weak points of the human factor, where this information will provide improvement in the material implementation of human factor training. This research is a descriptive study, where data obtained from online questionnaires will be analysed based on the HFACS. The population is aircraft maintenance technicians graduated from Surabaya aviation polytechnic for 410 people distributed in various MRO companies with samples taken for 186 people according to Herry King Nomogram, with a confidence level of 95%. The results of the analysis using the HFACS of the highest percentage are unsafe act operators, precondition for unsafe, unsafe supervision, organizational influence which is necessary to strengthen and enrich the syllabus of human factors on topic of human error, performance management, communication skill, situation awareness and reporting and investigating errors.

1. Introduction

According to Directorate of Airworthiness and Aircraft Operations, more than 381 aircrafts have been operated by the Air Operator Certificate (AOC) in Indonesia [2]. Based on the National Transportation Safety Committee (NTSC) report (2013), 60% of the causes of aircraft accidents in Indonesia were caused by human factors and total of aircraft accidents doubled in the last two years (2014 – 2016)[20][13]. In order to reduce the high quantity of aircraft accidents due to human factors, ICAO issued Standards and Recommended Practices (SRP) which were followed up by the Indonesian government with the issuance of regulations regarding the necessity to attend human factor training for technician in accordance to Civil Aviation Safety Regulation (CASR) Part 121, Part 135 and Part 145 [2].

Surabaya aviation polytechnic has graduated an aircraft maintenance engineering diploma program since 2010 and its graduates have spread to several MROs throughout Indonesia [16]. All courses in a curriculum contribute to the development of attitudes, skills, and knowledge [19]. The syllabus of human factors as the basis for forming the understanding and character of technicians plays a significant part to reduce the number of aircraft accidents. One way to review the educational
curriculum is to observe the performance of technicians who have graduated from the training [11]. Curriculum review based on current technician performance is expected to be able to contribute to the improvement of syllabus towards better aircraft technician performance.

2. Methodology

The performance of aircraft maintenance technicians can be observed through questionnaires that explore the error data that is frequently done by technicians in aircraft maintenance. HFACS is a method that can be used to analyze errors in aircraft maintenance as used for analysis and classification of causes of aircraft accidents in various countries in the world, including the United States [17], German [5] and China [10]. From the HFACS analysis method, it can be identified maintenance errors caused by human factors and classifying errors to determine the dominant factors in human error so that it can be given reinforcement in the syllabus of the human factor course.

This research is descriptive, where data are obtained from online questionnaires collected for analysis based on the theory of HFACS [18]. The online questionnaire included questions that would explore the type of minor event, the place where the minor event occurred, the time the event did the minor event and the type of minor event in the human factor layer. The object in this study were aircraft maintenance technicians graduating from Surabaya Aviation Polytechnic Diploma with a population of 410 people. Determination of the sample is based on Herry King Nomogram, with a population of 410, at the error level of 5% (95% confidence level), the number of samples taken is 0.38 x 410 x 1,195 = 186,181 or 186 people [18]. Total cases of errors in aircraft maintenance activities (minor events) collected from 186 diploma graduates of Surabaya Aviation Polytechnic are 210 minor events which will be examined and grouped according to HFACS method.

3. Result and Discussion

Based on the 210 cases collected through online questionnaires after being identified and grouped based on HFACS, data can be presented as the table below.

| Table 1. Minor Event of Aircraft Maintenance |
|---------------------------------------------|
| Layer                                    | Minor event of Unsafe act operators | Minor event of Precondition for unsafe act | Minor event of Unsafe supervision | Minor event of Organizational influences |
| Decision Errors                          | 62                                  | Physical / mental limitation               | 18 Inadequate Supervision          | 12 Organizational Climate                |
| Perceptual Errors                        | 31                                  | Adverse mental states                     | 24 Plan Inappropriate Operation    | 15 Resources management                 |
| Sub Layer                                |                                      |                                          |                                 | 7 Operational Process                   |
| Skill-Based Errors                       | 0                                   | Personal readiness                       | 17 Fail to Correct Known Problem   |                                               |
| Routine Violations                      | 0                                   | Crew resource Mismanagement              | 11 Supervisory Violation           |                                               |
| Exceptional Violations                   | 0                                   | Adverse Physiological State              | 0                                 |                                               |
| Total minor event                        | 93                                  | 70                                      | 27                                 | 20                                      |
3.5. Classification of Minor Event

According to figure 1, there are four classifications of minor events with the highest of percentage are unsafe act operator and the lowest are organizational influences.

a) Unsafe Act Operator.

The unsafe act operators layer ranks first with a percentage of 44.3%. This shows that in the unsafe act operator layer there are many errors in aircraft maintenance. In this layer the highest percentage is caused by decision errors (67%). The next type of error is perceptual error with a percentage of 33%.

At the unsafe act operators layer there are minor events in the decision error sub-layer category of 63% and minor events in the perceptual error sub-layer category with a percentage of 33%. According to questionnaire data, this occurs as a result of the lack of concentration of technicians when carrying out a maintenance task, failure to prioritize tasks maintenance, delayed necessary action, wrong choice of action during task maintenance. Focus in completing a maintenance task is absolutely necessary in order to be able to make the right decision on several possible causes of damage. Focus will accelerate decision making precisely and accurately [6]). Minor events in the perceptual error sub layer category occur because the checklist is not followed correctly, the procedure not followed correctly. This happens because of personnel weaknesses in remembering procedures, negligence and low accuracy [12]. Almost the same value obtained from the analysis of human factors on the type of slip and lapses error which ranks first with a percentage of 55% shows that slip and lapses are human errors in aircraft maintenance caused by negligence factors and accuracy of personnel[16].
b) Precondition for Unsafe Act.

In the precondition for unsafe act layer there are minor events with a percentage of 33.3%. The precondition for unsafe act minor events occur due to adverse mental states by 34%, due to physical / mental limitation factors of 26%, personal readiness by 24% and crew resource mismanagement by 16%.

![Fig. 3. Precondition for Unsafe Act Sub Layer](image)

At the precondition unsafe act layer, there are a number of minor events which are at the 34% adverse mental states sub-layer, 26% physical / mental limitation, 24% personal readiness and 16% crew resource mismanagement. Minor events in the sub-layer adverse mental states category occur because of life stressors, mentally exhausted (burnout). High stress levels trigger minor events on aircraft maintenance [15]. Minor events in the physical / mental limitation sub-layer category are caused by fatigue. This means that maintenance errors are caused due to fatigue and physical and mental limitations. Implementation of maintenance activities in a state of fatigue has the potential for error [7][21]. Minor events in the personal readiness sub-layer category occur because of overconfident factors. Overconfident harmfully affects the performance of technicians because it causes a lack of preparedness of personnel and tends to ignore the attitude of awareness of potential hazards [22]. Minor events in the sub-layer crew resource mismanagement category are caused by factors Failed to effectively communicate and Task / mission planning / inadequate briefing. Communication is a means to convey a common goal. Communication errors between personnel trigger errors in aircraft maintenance activities [9]. To overcome this condition, it is necessary to improve the training curriculum so that aircraft maintenance technicians are more alert and ready and able to communicate better both oral and verbal.

c) Unsafe Supervision.

In the unsafe supervision layer, there are several minor events in aircraft maintenance activities with a percentage of 12.8%. This shows that there are still errors in supervision activities which consist of inadequate supervision by 44% and planned inappropriate supervision by 56%.

![Fig. 4. Unsafe Supervision Sub Layer](image)
The unsafe supervision layer contained 12.8% minor events with the composition of the inadequate supervision sub-layer at 44% and the planned inappropriate supervision at 56%. Minor events in the inadequate supervision sub-layer occur because of failed to provide proper training. Current competency is the main requirement of maintenance activity. Failed to provide proper training caused competency not current. Proper training will avoid failures, reduce maintenance related accidents, and improve safety and reliability [4]. Minor event in the planned inappropriate supervision sub-layer caused by select supervisor with lack of current or limited experience [1]. Preventing minor events in the planned inappropriate supervision sub-layer by choosing the right supervisor with current competency and also conducting training for supervisors so as to make competent supervisors to support the performance of aircraft mechanics to reduce trouble.

d) Organizational Influence.

In the organizational influence layer, there are a number of minor events with a total percentage of 9.5%. Minor events at this layer consist of organizational process 65% and resource management 35%.

![Organizational Influences sub layer](image)

In the organizational layer, there are a number of minor events with a total percentage of 9.5%. Minor events at this layer consist of 65% organizational process sub-layer and 35% resource management sub-layer. Minor events in the sub-layer organizational process occur because of ineffective maintenance management procedures. Effective procedures can reduce costs and time[8]. There is a compact MIP model for the Operational Aircraft Maintenance Routing Problem (OAMRP) that offers a diagram decrease procedure and valid inequities that purpose to refining the solvability model [3]. Minor event at resource management sub-layer caused by time limitation and lack of spare parts stock. The repair in the airline industry is very severely carefully planned. Spare part register administration is one of the airline's tactics to keep the operational readiness and diminish the needless lost time such as delay and cancelation due to component failure [14].

3.6. Mapping Strengthening Human Factor Training Material

Surabaya aviation polytechnic already has a syllabus from the human factors course as shown in table 2. From the syllabus we can find out some of the material taught to trainees to shape the attitudes, skills and knowledge of a technician. Based on minor events that occur, it can be seen the weak points in layers and sub layers based on the classification of human factors. From this mapping, efforts can be made to strengthen and enrich the syllabus of the human factor courses as shown in the following table.
| No | Layer / Sub Layer | Weak Point | Enhancement Syllabus |
|----|------------------|------------|---------------------|
| 1  | Unsafe act operators | Minor events | Human errors |
| a  | Decision error | Failure to prioritize tasks maintenance | Error models (latent and active). |
|    |                   | Delayed necessary action | Error arrangement and prevention. |
|    |                   | Wrong choice of action during task maintenance | Job analysis: taking the initiative; “plan-do-check”; others. |
| b  | Perceptual error | Checklist not followed correctly | Fortifications: documentation; don’t take up, crisscross and examine others. |
|    |                   | Procedure not followed correctly | Changing environments rather than Shifting people. |
|    |                   |                          | Categories of error in maintenance jobs |
|    |                   |                          | Consequences of errors (i.e. coincidences) |
| 2  | Precondition for unsafe act | Minor events | Performance management |
| a  | Physical / mental limitation | Fatigue | Pressure: detecting stressors e.g. communication, role struggle, others. |
| b  | Adverse mental states | Life stressors | Pressure: be controlled, get help and facts, and give. |
|    |                   | Mentally exhausted (burnout) | Shift work: tiredness, working hours, slumber, trauma, and ecological factors. |
| c  | Personal readiness | overconfident | Satisfaction: documentation and management |
| d  | Crew resource mismanagement | Failed to effectively communicate Task/mission planning/briefing inadequate | Fitness/health |
|    |                   |                          | Time pressure and limits |
|    |                   |                          | Workload: overwork and under capacity |
|    |                   |                          | Alcohol, medication, drug abuse. |
|    |                   |                          | **Communication skill** |
|    |                   |                          | Understanding the significances of unfortunate communication. |
|    |                   |                          | Communication procedures (written, verbal, etc.). |
|    |                   |                          | Communication satisfied: relevance, perfection, conciseness and fullness. |
|    |                   |                          | Communication determination and object audience. |
|    |                   |                          | Communication performance: confidence, hostility and response. |
|    |                   |                          | Dynamic listening, response, physical response and facial communication. |
|    |                   |                          | Current writing. |
|    |                   |                          | Recognizing correct or incorrect data. |
|    |                   |                          | Overwhelming blocks to the use of correct data. |
| No | Layer / Sub Layer | Weak Point          | Enhancement Syllabus                                                                 |
|----|------------------|---------------------|-------------------------------------------------------------------------------------|
| 3  | Unsafe supervision | Minor events        | Shifting throughput process Within and between teams | Situation awareness |
|    | a Inadequate supervision | Failed to provide proper training | Error chain acknowledgement and control. |
|    |                  | Selected personnel with lack of proficiency | Workload management: wisdom to give or take no. |
|    | b Planned inappropriate supervision | Selected technician with lack of current or limited experience | Management, control and headship. |
|    |                  |                     | Concern: individual and group Enthusiasm and de-motivation Peer pressure ‘Ethos’ concerns Group working |
| 4  | Organizational influences | Minor events | Reporting and investigating errors |
|    | a Organizational process. | Ineffective procedure maintenance management | Corporate and state controlling requirements. |
|    | b Resources management | Time limitation Lack of spare part stock | Resistance statements and corrective issues. Private reporting systems. Analysis accountabilities and procedures Repairs error data investigation and writing of results Advice Board judgement-making |

4. Conclusion

Based on HFACS it can be concluded that referring to several cases of aircraft maintenance errors caused by human factors, it is necessary to strengthen and enrich the syllabus of human factors, especially on the topic

a. Human errors
   1. Error models (latent and active).
   2. Error Classification and prevention.
   3. Task analysis: be proactive; “plan do check”; others,

b. Performance management
   1. Fitness/health
   2. Time pressure and deadlines
   3. Workload: overload and under load

c. Communication skill
   1. Communication methods (written, verbal, etc.).
   2. Communication content: relevance, correctness, conciseness and completeness.
   3. Communication Purpose and target audience.

d. Situation awareness

e. Reporting and investigating errors
   1. Management decision-making
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