

Aviation Safety: Human Errors in Aircraft Maintenance that Affect the Welfare and Security of Passengers in Aviation Industry

Juanito II B. Caguimbal¹, Mark Caingles², Matt Ivan Victor Binasahan³, Ernest Jomaru E. Caranto⁴, Andrew Gatbonton⁵, Jerome Juanaya⁶, Enrico Jr. C. Mendoza⁷, Keizer Kent Palma⁸, Paul Vincent Pastor⁹, Dr. Marianne Shalimar G. Del Rosario¹⁰

^{1,2,3,4,5,6,7,8,9,10}Student, PATTS College of Aeronautics

Abstract

This research delves into the complex realm of human errors in aircraft maintenance, emphasizing their profound impact on the safety and security of passengers within the aviation industry. Employing a phenomenological research design, the study explores the experiences, viewpoints, and insights of licensed aircraft maintenance personnel in the Philippines through interviews. The qualitative approach, coupled with thematic analysis, unravels the multidimensional nature of human errors, encompassing individual decision-making to organizational and systemic factors. The "Dirty Dozen" factors, a recurrent theme in aviation safety, are identified as significant contributors to incidents and accidents. The study underscores the importance of awareness and training programs to address these factors proactively, fostering a safety-focused culture among aviation professionals. The impact of human errors on the aviation industry's safety and security was thoroughly examined, emphasizing the necessity of continual learning and preparedness through structured training initiatives. The research also identifies tools and strategies for lessening the occurrence of human errors, including safety risk reduction measures, safety procedures, and in-depth risk assessments. The study's findings contribute to a deeper understanding of human errors in aviation maintenance, providing valuable insights for aviation students, maintenance personnel, instructors, airports, and the broader aviation industry. By acknowledging and addressing these factors, the industry can enhance safety protocols, reduce risks, and cultivate a culture of safety awareness.

Keywords: Aviation Safety, Human Errors, Aircraft Maintenance, Safety Risk Reduction, Dirty Dozen.

I. INTRODUCTION

In the discussion of civil aviation safety, the term "Human Error" is frequently used. This conduct destroys property and equipment when people neglect to complete the assigned task by the established plan. An unexpected aircraft disparity caused by an aviation maintenance technician's efforts is referred to as a maintenance error. The vast majority of human activity relies on the undertaking, the environment, and the individual. Maintenance workers must meet the growing need for enhanced safety levels from both the commercial aviation industry and passengers. Minimizing human mistakes in aircraft maintenance. The development of research and technology has made human error the most significant contributing

factor to maintenance accidents in civil aviation, surpassing mechanical failure.

This study looked at the subjective factors influencing the weariness of line maintenance crews as well as the psychological and physiological variations in shift employees' levels of exhaustion (Wang & Chuang, 2014). To gain a better understanding of maintenance errors, it is essential to understand the tasks and environment of the aircraft maintenance technician Marx & Graeber (2019). It was also discovered that organizational factors when combined with the human factors construct, contributed to human errors (Padil, Said & Azizan, 2018). The availability of resources and other human factors, such as the overall organizational environment, have a significant impact on maintenance activities, particularly in terms of the sufficiency and proper application of maintenance instructions (Zimmermann & Mendonca, 2021). The specific goal of Human Factors in aircraft accident and incident investigation is to understand in detail how and why humans make errors (including slips and lapses) or conduct violations that lead to accidents. (Adams, 2006). The factors associated with aviation maintenance jobs that could be simply and effectively addressed include unpleasant physiological states, physical/mental limits, coordination, communication, and planning (Chiu & Hsieh, 2016). Twelve human factors could lead to maintenance errors using the human factor theory and comprehensive analysis and research on maintenance-related aviation accidents and incidents caused by human error (Cheng, 2018). Communication and procedures followed contribute the most to the existence of human error, as it is inevitable (Hawwach, 2021). Human error is significantly influenced by a pilot's self-efficacy. It shows self-efficacy, work engagement, and human error are correlated with each other which influences the pilot's performance during in-flight missions. Different kinds of human error can affect product quality and overall effectiveness. One way to measure human error is through human reliability models, which are frequently used for HEP computation and error identification. HEART, THERP, and SLIM are the most used dependability measurement techniques, and their utilization varies by application and industry. (Hawwach, 2021). Self-efficacy, work engagement, and human error were all found to be highly connected with one another using correlation analysis. Aviation human error was highly influenced by aircraft maintenance self-efficacy, according to a causal stepwise regression and bootstrap study. (Li, et al., 2021).

Between 12 and 15% of all aviation accidents worldwide are the result of aviation maintenance errors; when significant occurrences are taken into consideration, this percentage jumps to 23%. (Rashid, Place & Braithwaite, 2013). The most notable errors are those that result in accidents, but maintenance and inspection mistakes also have significant repercussions that reduce airline production and efficiency and inconvenience passengers (Latorella & Prabhu, 2000). Three separate hazard patterns, representing the active failures, were found to account for 81% of all ground damage incidents out of the twelve distinct hazard patterns (Wenner & Drury, 2000).

The significance of safety measures, such as ongoing training on maintenance human factors, will be underlined by examining prior accidents and problems brought on by aviation maintenance mistakes (Jiang et al., 2022). Risk mapping is created so that managers can use it to determine which risk management strategy to use. The risk map is a tool that managers can use to decide on risk management solutions as well as to discuss sources of risk management and establish their managerial priorities. This new model could be an effective new instrument for managing ergonomic human factor-based hazards while creating a strategy in aviation business management. (Kucuk Yilmaz, 2019). Improving technician competency evaluation processes has the potential to reduce maintenance errors, increase technician performance, have a positive impact on safe and efficient flight operations, lower maintenance costs, and benefit the overall aviation industry. (Gunes, Turhan & Acikel, 2020). Screening for persons who are very

risk-averse or overly comfortable with accepting risks might assist hiring managers in employing the correct staff prepared to make suitable decisions in high-risk industries such as aviation. Furthermore, by encouraging and assessing hazard reports, efforts can be taken in the future to reduce human error components (Mrusek & Douglas, 2020). The success of the airlines that have been using information more effectively over time and the testimony that is so common in accident hearings that "we all knew about that problem" revealing that problems were known but not addressed have both served as examples of the value of doing so to break through the plateau. (Hart, 2002). The tendency is to implement the technique by continuous monitoring and analysis of faults in aviation maintenance in the EASA-approved aircraft maintenance organization, which incorporates the human aspect into its working system (Virovac, Domitrović & Bazijanac, 2017).

Various human factors contribute to the continuous occurrence of human errors thus impacting the safety and security of the passengers. Providing adequate training and knowledge on aircraft maintenance must be a priority for maintenance personnel to be able to achieve its number one priority which is safety. Human errors are one of the top most contributing factors to aircraft accidents and incidents worldwide which affects the majority of the aviation industry in many aspects.

1.1. Background of the Study

For both regional and global connectivity, the Philippines heavily relies on air transport. It must be done to ensure the safety and security of aviation operations not only for the protection of passengers and crew but also for the country's economic growth and global reputation.

Over the previous few decades, the Philippine aviation industry has risen tremendously. With more airlines operating, new airports being developed, and increased air travel demand, the aviation industry has become a significant component of the country's infrastructure and economic growth. This rapid expansion, however, has sparked worries about the industry's ability to maintain and improve aviation safety standards as it grows. The Philippine aviation industry has seen its fair share of safety mishaps and issues. From minor events to severe accidents, the sector has faced difficulties ranging from technical faults to human mistakes. These events have, at times, resulted in injuries, fatalities, and aircraft damage, prompting concerns about the sector's broader safety culture, regulatory oversight, and operational standards.

As an active member of the global aviation community, the country's capacity to meet international safety standards is critical for sustaining international air connectivity, attracting foreign investment, and boosting tourism. Failure to satisfy these requirements may result in international sanctions and harm to the country's reputation.

Human factors have an important influence on aviation safety. Analyzing training programs and practices for aviation employees, such as pilots, air traffic controllers, and maintenance crews, is critical to determining potential causes of mistakes and areas for improvement in safety standards.

1.2. Theoretical Framework

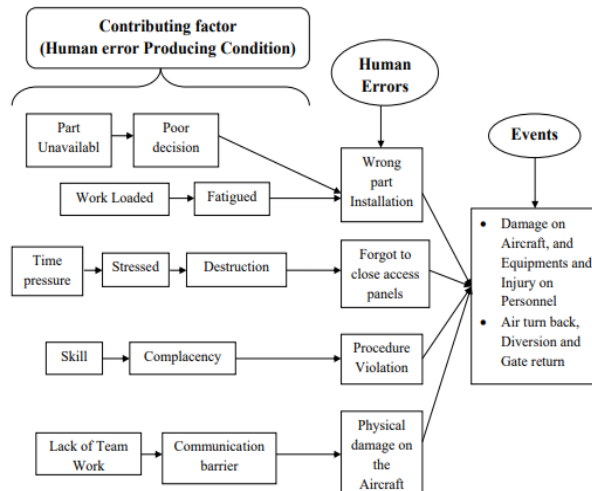


Fig. 1: The MEDA Investigation Process

The Boeing Maintenance Error Decision Aid (MEDA), which focuses on documenting human error-based variables that contribute to an event, serves as the foundation for a maintenance safety program. Effective preventative measures can be developed and implemented by using an organized, unbiased analysis of undesired events, correctly identifying cause elements, and using a database system.

In this model, a contributing component or factors contribute to an error that results in an event. In MEDA, the phrase "contributing factor" is used to indicate circumstances of wrongdoing. Anything that has an impact on a maintenance technician's or inspector's performance is merely a contributing element.

1.3. Conceptual Framework

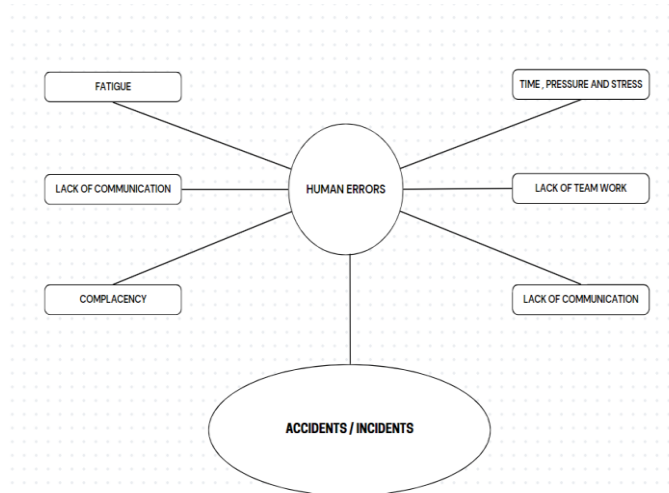


Fig. 2: Diagrammatic Depiction of Contributing Factors

Figure 2 is the conceptual framework based on the MEDA Investigation Process diagram. This describes the causes of human mistakes that result in airplane accidents and incidents occurring frequently. Human errors are the center of this diagram as it is the main focus of this study.

Understanding each discipline and using it to analyze various contexts or human behaviors allows us to accurately identify potential human factors and handle them before they become a problem or set off a cascade of issues that lead to an accident or incident.

1.4. Statement of the Problem

The study aimed to identify the factors, assess the impact, and minimize the occurrence of human errors in maintenance that risk the safety and security of passengers in the aviation industry.

Specifically, the study sought the answers to the following questions:

1. What are the factors that lead to human errors of maintenance ?
2. What is the impact of human errors of maintenance on the aviation industry in terms of the safety and security of passengers?
3. How to lessen the occurrence of human errors related to aircraft accidents?
4. What is the frequency of aircraft accidents due to human errors of maintenance from 2003 - 2019

1.5. Significance of the Study

This study would benefit the following:

Aviation Students - Students can gain important research skills, such as data collecting, analysis, and interpretation, by doing or taking part in research on aircraft maintenance and human errors. Aviation students can acquire tactics for identifying, preventing, and reducing human maintenance faults. These abilities are adaptable and can be used in a range of professional contexts.

Aviation Maintenance Personnel - This study provides vast information about contributing factors that lead to human error, safety procedures, and the impact of human errors. With this Aviation Maintenance Personnel will be able to have awareness which can result in the reduction of occurrences of human errors that will be beneficial to the safety and security of the aviation industry.

Aircraft Maintenance Instructors - This research will be beneficial to AMT instructors as it will open awareness of human errors in the aviation industry in educating students. This creates a safer environment and reduces the likelihood of accidents and incidents.

Airports - Provide access to a variety of aircraft models, enabling researchers to study human errors in various aircraft types. This variety can aid in comprehending how different human errors can occur depending on the complexity of the aircraft.

Aviation Industry - The results of the study may be an eye-opener for the development of safety briefings before and after flight operations. That may lessen human and mechanical errors in the aviation industry.

For Future Researchers - This study is beneficial for future researchers as it aims to provide awareness and improvements on safety procedures to minimize the risk and occurrences of human errors that can potentially lead to accidents or incidents in the aviation industry.

METHODOLOGY

2.1. Research Design

The researchers chose to conduct a pure qualitative research with different approaches. A meta-analysis is used to gather and compare information from different studies to support the research. Thematic Analysis is also used for the researchers to be able to emphasize the information gathered from the informants. Using a qualitative approach, it is possible to gain a complex understanding of human errors, their origins, effects, and potential remedies. Aviation maintenance creates massive amounts of textual data, including incident reports, maintenance logs, safety records, and interviews. Text analysis tools can effectively handle and evaluate this textual material, making it easier for researchers to manage. Human error in aircraft maintenance is frequently multidimensional, involving a variety of causes ranging from individual decision-making to organizational and systemic concerns. By finding and categorizing themes

that arise from data, thematic analysis allows researchers to examine and comprehend these intricacies. Documented studies and literature reviews offer researchers with a solid basis of existing knowledge and study findings linked to human error in aircraft maintenance. This assists researchers in understanding the present state of the topic and identifying gaps or areas that require additional inquiry.

2.2. Respondents

The informants of the study are current Licensed Aircraft Maintenance personnel working in the Philippines with adequate work experience. The researchers have decided on the qualifications of the respondents as it will help gain accurate data and results for the study. An expert from the field of Air Transportation was also a part of this study as they are knowledgeable on human factors that lead to human errors. Furthermore, an AMT instructor was also involved in this study because the experience and knowledge that he has will be a huge contribution to the success of the research.

2.3. Settings

This study aimed to provide a comprehensive understanding of human errors in aircraft maintenance, their causes, consequences, and strategies for mitigation. It also emphasizes the importance of a multi-disciplinary approach that incorporates human factors, safety management, and technological advancements to enhance aviation safety and maintenance practices. The limitation of this study surrounds only the human errors in aircraft maintenance excluding other fields such as pilots, flight dispatchers, and flight operations officers.

2.4. Instrumentation

The researchers were able to construct questions to be input for the validation questionnaire and as guide questions for data analysis. To improve the accuracy and precision of the information flow in the study, three experts from different fields were assigned as validators. They were responsible for carefully looking over and evaluating every guide question to make sure everything had been carried out carefully and thoroughly. Through this cooperative effort, the study's methodology was improved, resulting in a stronger and more dependable framework for data collection and analysis. The results were used as a basis for guide questions which are approved and assessed by the validators and it is used for this study.

2.5. Data Analysis

The relevance of each research question to the study is evaluated. Meta-analysis was used in this study to evaluate and compare various studies connected to human errors of maintenance in the aviation industry. A thematic analysis was also used to explain the conducted interview thoroughly.

2.6. Ethical Considerations

The researchers were mindful of some ethical concerns that needed addressing. To ensure the privacy and security of the personal information of the students involved in the study, the researchers promised to keep it strictly confidential. The researchers conducted the study with utmost professionalism and accuracy, recording and tabulating all data without any manipulation. The entire research process was conducted with transparency and honesty. The researchers also took care to explain the research to the students and ensured that students fully understood the research process. This not only protected the integrity of the data but also informed the students about the purpose and significance of the research.

III. RESULT AND ANALYSIS

3.1. The Contributing Factors that affect human performance which lead to human error in aircraft maintenance.

GUIDE QUESTIONS	R1	R2	R3	R4
What are the subjective factors influencing the weariness of line maintenance crews and the psychological and physiological variations in exhaustion levels among shift employees ?	Dirty Dozen	Dirty Dozen	Dirty Dozen	Dirty Dozen
What approaches or tools are available for assessing and measuring professional levels of fatigue, stress, and pressure exposure?		Proactive and Reactive Approach	Proactive and Reactive Approach	Proactive and Reactive Approach
How do organizational factors interact with the human factors constructed to contribute to human errors?		Awareness	Awareness	
How do the availability of resources and the organizational environment affect the sufficiency and proper application of maintenance instructions in maintenance activities?		Proper Management	Proper Management	Proper Management
What methods and approaches are typically used in Human Factors investigations in aircraft accidents and incidents to gain a detailed understanding of how and why humans make errors or conduct violations that result in accidents?			Advanced Systems	Advanced Systems
What are the simple and effective methods for dealing with aspects such as unpleasant physiological states, physical/mental constraints, coordination, communication, and planning in aircraft maintenance jobs?		Maintenance Training Programs		Maintenance Training Programs
What are the human factors identified in maintenance-related aviation accidents and incidents caused by human error according to the human factor theory?	Dirty Dozen	Dirty Dozen	Dirty Dozen	Dirty Dozen

How does the role of communication and procedures contribute significantly to the existence of human error, considering its inevitability?		Lack of Coordination	Lack of Coordination	
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Table 1: Contributing Factors

In the aviation industry, human errors create a huge difference and affect the performance of personnel especially with aircraft maintenance. There are various contributing factors or human factors that increase the possibility of human error occurrence within aircraft maintenance that lead to accidents and incidents in the industry thus specific procedures and safety recommendations are applied to reduce the occurrence of human error.

Based on various studies, the main contributing factors are within the dirty dozen. The term "Dirty Dozen" in aviation refers to a concept related to human factors and safety management. It is a list of twelve common human errors or organizational factors that can lead to aviation accidents. The Dirty Dozen is often used in aviation safety training to raise awareness about these potential hazards and to emphasize the importance of addressing them to prevent accidents.

Addressing the Dirty Dozen factors is crucial for maintaining a safe aviation environment. Aviation organizations, regulatory bodies, and individuals involved in aviation must work to mitigate these factors through training, safety programs, and a culture of safety awareness. By recognizing and addressing these human errors and organizational factors, the aviation industry can reduce the risk of accidents and enhance safety for all stakeholders.

The aviation industry calls the most frequently recurring factors that lead to incidents ‘the Dirty Dozen.’ The ‘Dirty Dozen’ includes, for example, stress, distractions and interruptions, team norms etc. (Carthey, 2019).

3.2. The impact of human errors of maintenance on the aviation industry in terms of the safety and security of passengers?

Questions	R1	R2	R3	R4
How can the aviation industry work to lessen the incidence of such errors in order to lessen the high percentage of accidents they cause, especially when significant occurrences are taken into account?	Awareness	Awareness	Awareness	Awareness
What are the notable repercussions of maintenance and inspection errors in the airline industry, beyond accidents, that lead to	Lack of Assertiveness	Lack of Assertiveness	Lack of Assertiveness	

reduced production efficiency?				
What are the visible main hazard patterns that account for 81% of ground damage occurrences brought on by active failures, and what steps might be made to lessen their frequency in order to improve aviation operations' safety?			Active and Latent Failures	

Table 2: The Impact of Human Errors

In the dynamic and safety-critical environment of the aviation industry, the importance of awareness and training programs cannot be overstated. These programs are at the forefront of efforts to minimize human errors and ensure the highest standards of safety throughout the aviation sector.

Awareness and training programs are cornerstones of safety efforts in the aviation industry, serving as proactive measures to reduce human errors. These programs instill a safety-focused culture by educating aviation professionals on the importance of adhering to strict safety protocols and being vigilant at all times. They also emphasize the significance of understanding human factors that can contribute to errors, allowing individuals to recognize and mitigate their own vulnerabilities. Through regulatory compliance, risk management, and continuous learning, these programs contribute to a safer aviation environment, ensuring that personnel are well-prepared to handle emergencies and evolving challenges effectively.

The aviation industry relies heavily on meticulous awareness initiatives and structured training programs to minimize human errors and bolster safety protocols. These programs immerse aviation personnel in a culture of continuous learning and preparedness, instilling a proactive mindset to anticipate and mitigate potential risks. By emphasizing situational awareness and hands-on experience, such initiatives not only refine technical skills but also cultivate a collective mindset geared towards error prevention, significantly reducing the likelihood of safety-related incidents within the industry.

Aircraft maintenance is one of the primary causes or contributing factors in aircraft accidents. Proper training of Aircraft Maintenance Technicians (AMTs) will avoid failures, reduce maintenance-related accidents, improve safety and reliability in aviation, and provide recovery of the increasing demand for qualified AMTs for the sustainability of the market growth (Dalkilic, 2017).

3.3. The ways to lessen the occurrence of human errors related to aircraft accidents

Questions	R1	R2	R3	R4
What insights can be gained by analyzing past aviation accidents and issues resulting from maintenance errors in order to emphasize the importance of safety measures, including continuous training on maintenance human			Proper Training Program	Proper Training Program

factors?				
How does the process of risk mapping aid aviation managers in selecting appropriate risk management strategies?		Accurate Risk Assessment	Accurate Risk Assessment	Accurate Risk Assessment
What specific measures or strategies can be implemented to enhance technician competency evaluation processes in the aviation industry ?			Strong educational and training program	
How can screening processes be effectively utilized by hiring managers in high-risk industries like aviation to identify individuals with the right balance of risk aversion and risk acceptance for making appropriate decisions?		Behavioral Assessment		Behavioral Assessment
What lessons can be learned from the success of airlines that have effectively used information over time and from the common testimony in accident hearings that problems were known but not addressed, highlighting the value of addressing known issues to overcome plateaus in safety and performance?				Successful Decision Making
How does the approved aircraft maintenance organization incorporate the human aspect into its working system while implementing the technique of continuous monitoring and analysis of faults in aviation maintenance?	Implementing system approach			Implementing system approach

Table 3: The Ways on How to Lessen Human Errors_

A vital component of guaranteeing people's safety and the prosperity of enterprises in a variety of sectors is safety risk reduction. To prevent accidents, injuries, or other unfavorable outcomes, it is necessary to recognize, evaluate, and mitigate possible dangers and threats. Organizations may improve operational efficiency, safeguard assets and personnel, and maintain their reputation for ethical business practices by taking proactive measures to address safety hazards.

Implementing safety procedures, carrying out in-depth risk assessments, and encouraging a safety-conscious culture inside a company are just a few of the many tactics and procedures that make up safety risk reduction. Employers can lower the risk of workplace accidents and cut down on the material and human expenses of occurrences by implementing these precautions. Additionally, as they feel more comfortable in their surroundings, workers' morale and productivity might benefit from safety risk reduction initiatives. Additionally, as they show a dedication to sustainability and moral business practices, companies that place a high priority on safety risk reduction typically attract more clients and

investors. In conclusion, safety risk reduction is a comprehensive strategy that promotes long-term profitability and stakeholder trust in addition to protecting people and property.

According to the research, safety risk reduction is a comprehensive, strategic approach that transcends short-term risk reduction. It helps a company establish a reputation for morality and environmentally friendly business practices and has a favorable impact on a range of aspects of the business, including staff satisfaction and its financial performance.

Kucuk Yilmaz (2019) stated that the Strategic approach to managing human factors risk in aircraft maintenance organizations is risk mapping.

3.4. The frequency of aircraft accidents due to human errors of maintenance from year 2003 - 2019

	%	<i>Frequency</i>
2003	26	12
2005	50	23
2011	65	35
2019	60	21
<i>Total</i>		91

Human errors play a vital role when it comes to aircraft accidents in which a slight mistake of aircraft maintenance personnel can create a huge disaster in the aviation industry. Each year the percentage of accidents due to human error is continuously progressing thus impacting the safety and security of passengers.

In 2003 , the International Air Transport Association reported that 26% of accidents with a frequency of 12 accidents are a result of human errors of aircraft maintenance in which most of these errors are latent errors whose actions have a delayed effect. In 2005, 50% of human errors were due to maintenance human factor problems having a total of 23 accidents. In 2011, human errors were responsible for 65% of the total aircraft accidents of that year. Lastly in 2019, 60% of accidents are due to human factors that lead to human errors in aircraft maintenance. This table shows that the total number of accidents due to human error is 91.

As the frequency of human errors progresses, various impacts are seen in the aviation industry which can affect the safety and security of passengers. Controlling human factors that lead to human error should be implemented to mitigate and lessen the occurrence of human errors.

Accidents resulting from maintenance errors not only will undermine the viability of the industry but will also represent a major cost for airlines (Berlowitz, 2019).

3.5. Thematic Analysis

Master Theme	Superordinate Theme
Contributing Factors that lead to human error	Stress

which cause accidents or incidents	Fatigue
Impacts of human errors to the safety and security of passengers	Accidents Incidents
Procedures to lessen the occurrence of human errors in aircraft maintenance	Training Programs

Master Theme 1: Contributing Factors that lead to human error which cause accidents or incidents

Superordinate Theme 1: Stress

Informant 1: Next is stress. So there are kinds of stress. So, of course, if you have fatigue, that includes physical, and we also have what we call mental or emotional stress.

Informant 2: The probable cause of human errors are the dirty dozen, so the dirty dozen comprises lack of communication, stress, fatigue, and many more so you can search that on the internet. These dirty dozen are a very crucial part when it comes to the safety and security in the aviation industry.

In the aviation field, certain contributing factors are vital when it comes to the performance of aircraft maintenance employees. These factors create a huge impact on the safety and security of the aircraft and passengers, thus proper procedures or tools are being implemented to reduce the risk of human errors.

The main contributing factors that are mostly occurring are stress which affects the physical and mental state of aircraft maintenance which contributes to poor performance. Stress can contribute to fatigue among maintenance personnel. Fatigue can lead to reduced concentration, slower reaction times, and impaired judgment, all of which are critical factors in ensuring the safety and reliability of aircraft maintenance.

Aircraft maintenance demands precision and attention to detail. Stress may result in personnel rushing through tasks, neglecting procedural steps, or overlooking critical details. This can compromise the quality of maintenance work, potentially leading to undetected issues or inadequate repairs that pose safety risks during flight operations.

It is very important to understand how the human body and mental process function and how performance limitations can influence a technician’s effectiveness at work, Evaluation of Stress Affecting Aircraft Maintenance Technician’s Performance (Yazgan, 2023).

Master Theme 1: Contributing Factors that lead to human error which cause accidents or incidents

Superordinate Theme 2: Fatigue

Informant 1: For that question, usually the factors are, number one, fatigue. Of course, if you're fatigued, you cannot function or think well or make proper decisions.

Informant 2: The probable cause of human errors are the dirty dozen , so the dirty dozen comprises lack of communication , stress , fatigue , and many more so you can search that on the internet. These dirty dozen are a very crucial part when it comes to the safety and security in the aviation industry . I think it concludes all of the factors that lead to human errors.

Informant 3: First is fatigue because when you overwork yourself you can experience overfatigue and that leads to human error.

One of the most vital contributing factors that lead to human errors in aircraft maintenance is fatigue. It affects the physical and mental state of an individual which can potentially pose a risk to the safety and security of passengers.

Aircraft maintenance demands precision and attention to detail. Fatigue can exact a cognitive toll, diminishing the ability of maintenance personnel to execute tasks with the required accuracy. From routine inspections to intricate repairs, the risk of oversight or procedural lapses increases, potentially compromising the safety of subsequent flights.

Recognizing and addressing the multifaceted nature of this challenge is pivotal for sustaining a safety-first culture in aviation. By implementing targeted mitigation strategies, stakeholders can strike a balance between operational excellence and the well-being of maintenance personnel, fortifying the foundations of aviation safety and reliability

The problem of maintenance staff fatigue is a serious challenge for aircraft maintenance organizations, and its solution is directly related to the impact on flight safety (Rybalkina, A., & Enikeev, 2021).

Master Theme 2: Impacts of human errors on the safety and security of passengers

Superordinate Theme 1: Accidents

Informant 1: As I mentioned earlier, due to the factors I mentioned, the most likely impacts are accidents. For example, if you're a maintenance personnel and you leave tools near the engine, and then the crew starts the engine. Of course, the tools left behind will be sucked in. So that will lead to an accident.

Informant 2: If the physical and mental state is affected thus the performance will also be affected, possibly leading to an accident or incident which we do not want.

Informant 3: For me there are two impacts of human error first is accident and incident.

The most common impact of human errors in aircraft maintenance in the aviation industry is accidents. Due to human factors that lead to human errors, the performance of aircraft maintenance employees is affected thus creating a possibility of resulting in accidents.

Based on the information from the informants, the connection between human errors and accidents is significantly seen as these errors create mishaps in the field. Lack of procedural awareness is one of the causes that lead to these accidents.

Accidents resulting from human errors in aircraft maintenance are reminders of the delicate balance between precision and fallibility in aviation. While the industry has made significant strides in enhancing safety protocols, continuous vigilance, comprehensive training, and a commitment to learning from past incidents are imperative to further reduce the incidence of maintenance-related accidents.

Between 70% and 80% of all aviation accidents are attributable to a human error somewhere in the chain of causation, the more efficient attempts to reduce the aviation accident rates are those that are developed upon a sound understanding and application of human factors (Sant'Anna & Hilal, A. V. G. de, 2021).

Master Theme 2: Impacts of human errors on the safety and security of passengers

Superordinate Theme 2: Incidents

Informant 1: For instance, if the cover on the pitot tube of an aircraft is not removed before flying. That is an incident.

Informant 2: The very obvious impact of human error is definitely accidents or incidents, but in connection to my answer to question number 1 the impact of dirty dozen is that it affects the physical and mental state of a certain employee. If the physical and mental state is affected thus the performance will also be

affected, possibly leading to an accident or incident which we do not want.

Informant 3: The readings are not accurate and the incident is when you drop a tool on an aircraft engine it can still fly but the damage can be very dangerous.

Another impact of human errors in aircraft maintenance is incidents. An incident is typically defined as an occurrence, other than an accident, associated with the operation of an aircraft that affects or could affect the safety of the operation.

Aircraft maintenance personnel tend to make certain mistakes about the aircraft itself in which based on the information from the informants, certain tools are misplaced or some procedures are not followed due to lack of awareness. With this, an incident may occur which can affect the safety and security of passengers in the aviation industry.

Human errors in aircraft maintenance leading to incidents are multifaceted challenges that demand a comprehensive and proactive approach. By understanding the root causes, and consequences, and implementing preventive measures, the aviation industry can work towards minimizing the occurrence of maintenance-related incidents. This analysis underscores the importance of a collective commitment from regulatory bodies, industry stakeholders, and maintenance professionals to uphold and enhance safety standards in aviation maintenance operations.

With the help of the human factor theory, through deep analysis and research into maintenance-related aviation accidents and incidents caused by human error, twelve human factors could lead to maintenance errors (Cheng, 2018).

Master Theme 3: Procedures to lessen the occurrence of human errors in aircraft maintenance

Superordinate Theme 1: Training Programs

Informant 1: Some companies have procedures that include weekly meetings where all maintenance personnel collaborate to plan the maintenance tasks for the week. This helps prevent errors, and during the meeting, if a maintenance personnel feels they are working overtime, that concern can be addressed and rectified.

Informant 2: It is very important to brief our employees so that they are aware of what to do and the objective of the company. Second is a progress check so that they can be able to track their performance and see if there are lacking activities. Lastly, enhancing training programs definitely in order to sustain a safe environment.

Informant 3: You need to go to some seminars like that or it depends on the company if they have a meeting every week to attend that meeting so you can learn some and can practice not to have human errors.

Human errors pose a risk to the safety and security of passengers thus mitigating these errors can create a huge impact on the aviation industry. Providing a safe environment for the passengers by implementing an advanced training program that will provide aircraft maintenance employees with adequate training and knowledge regarding safety procedures.

Maintenance tasks often involve collaboration among team members. Training programs emphasize effective communication and teamwork, fostering a cohesive and coordinated approach to maintenance operations. Training programs include simulations and scenarios that prepare maintenance personnel for emergencies. This ensures that they can respond effectively and decisively in critical situations, contributing to overall aviation safety.

Training programs are indispensable for maintaining the highest standards of safety, competence, and

professionalism in aircraft maintenance. By investing in the ongoing education and skill development of maintenance personnel, the aviation industry safeguards its operations and reinforces its commitment to the well-being of passengers and the integrity of air travel.

The risk of human error was defined in each task procedure to prevent human errors and improve satisfaction with the job (Liang et al., 2010).

IV. DISCUSSION

4.1. Conclusions

Based on the results and analysis, the following were concluded:

Human maintenance failures in the aviation industry present an important risk to passenger safety and security. To ensure the safe functioning of airplanes, the aviation industry relies significantly on complicated systems and strict procedures. Maintenance errors, which are frequently caused by human factors, could threaten the integrity of these systems and contribute to accidents or events with serious effects.

The vulnerability of maintenance systems to human errors is one of the important challenges in aviation safety. Fatigue, stress, insufficient training, and communication failures among maintenance people can all lead to errors in performing important jobs. These errors can create weaknesses in the aircraft's systems by misinterpreting maintenance instructions, overlooking critical stages, or poorly executing procedures. Providing the proper training programs can help reduce the occurrence of human errors. These training programs will help ensure that each personnel will abide by the regulations of the company regarding safety protocols or procedures to implement.

The percentage of accidents caused by human errors in aircraft maintenance is a critical factor influencing aviation safety. While advancements in technology and rigorous safety protocols have significantly reduced the overall risk of accidents, human errors remain a persistent challenge. The aviation industry continually strives to enhance training programs, implement strict maintenance procedures, and develop cutting-edge technologies to minimize the likelihood of human-induced mishaps.

4.2. Recommendations

Based on the discussed conclusions, the recommendations are as follows:

1. Aircraft maintenance training facilities may focus on human factors that lead to human errors by conducting seminars regarding the contributing factors such as the Dirty Dozen to reduce the risk and possibility of the occurrence of human errors.
2. Aircraft maintenance personnel shall ensure that each protocol will be followed per the approved maintenance training programs by having an aircraft maintenance manual which will enhance the safety and security of passengers in the aviation industry creating a lesser negative impact in the industry.
3. Airline companies and Maintenance Facilities can provide training programs that will develop and improve the quality of performance of each aircraft maintenance personnel to ensure that they can provide quality services.
4. Future Researchers and Aircraft maintenance students may be able to utilize this study for aircraft maintenance professionals to be able to gather information that will help lessen the frequency of accidents caused by human error

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