The Effect of Stress Due to Fatigue, Flight Duration, and Situation Awareness on Pilot Flight Performance

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ABSTRAK

Pada penelitian ini memiliki tujuan untuk mengkaji beberapa faktor pengaruh stres yang diakibatkan oleh keadaan kelelahan (fatigue), durasi penerbangan (flight duration), dan kesadaran situasional (situation awareness) yang berpengaruh pada performa terbang pilot. Penelitian ini menggunakan metode penelitian kajian pustaka (library research) dengan mengumpulkan dan menganalisis literatur yang terdapat pada berbagai jurnal, artikel ilmiah, maupun sumber pustaka terkait. Penelitian ini akan mengidentifikasi bahwa fatigue, serta situational awareness, dan flight duration atau durasi penerbangan yang panjang merupakan faktor penyebab peningkatan tingkat stres, yang secara signifikan menyebabkan terganggunya kemampuan kognitif, pengambilan keputusan, dan konsentrasi pada pilot selama menjalankan penerbangan. Ketika pilot memiliki tingkat situational awareness yang tinggi maka dapat berdampak sebagai faktor mitigasi yang dapat mereduksi dampak negatif stres terhadap performa terbang dari pilot. Temuan dari penelitian dan kajian literatur ini diharapkan dapat memberikan dasar sebagai pengembangan strategi untuk manajemen stres dan untuk peningkatan mengenai situational awareness yang memiliki dampak untuk keselamatan dan keamanan penerbangan karena mempengaruhi performa dari pilot untuk pengambilan keputusan (decision making) dalam situasi darurat (emergency condition).

Keyword : *Performa terbang, fatigue, flight duration, dan situational awareness.*

ABSTRACT

This study aims to examine several factors that influence stress caused by fatigue, flight duration, and situational awareness that affect pilot flight performance. This study uses a literature research method by collecting and analyzing literature found in various journals, scientific articles, and related literature sources. This study will identify that fatigue, situational awareness, and long flight duration are factors that cause increased stress levels, which significantly disrupt cognitive abilities, decision making, and concentration in pilots during flights. When pilots have a high level of situational awareness, it can have an impact as a mitigation factor that can reduce the negative impact of stress on pilot flight performance. The findings of this research and literature review are expected to provide a basis for developing strategies for stress management and for improving situational awareness that has an impact on flight safety and security because it affects pilot performance for decision making in emergency situations.

Keywords: *Flight performance, fatigue, flight duration, and situational awareness.*

INTRODUCTION

Understanding the impact of stress on pilot performance is crucial, as high workloads can significantly impair their ability to operate effectively. Research has shown that various types of stress encountered during flight can negatively affect pilot performance. Studies indicate that excessive cognitive load during duty can be especially detrimental in critical phases or emergency situations. In these moments, pilots may struggle to execute established flight procedures, increasing the risk of operational errors.

During critical phases and emergencies, heightened stress can slow response times and impair decision-making abilities—two essential factors for ensuring flight safety. Given the significant influence of stress on pilot performance, it is vital to recognize its effects and implement strategies to mitigate them. A well-structured training program, along with a strong support system, can help reduce pilot stress levels and enhance self-awareness, ultimately fostering safer and more efficient flight operations (Bendak & Rashid, 2020). As a result of numerous studies and incidents in aviation, it has been shown that pilot safety and performance depend not only on their experience and technical skills, but also on psychophysiological conditions such as stress. Some of the most common internal and external factors causing stress are fatigue, flight duration, and situational awareness.

This condition is certainly very dangerous considering that the pilot must have time to respond to emergency situations quickly and accurately. In addition, the long flight duration is also an important factor that adds to the workload that can trigger pilot stress. Because the longer the pilot is in a flying situation, especially on long-haul flights or with a tight schedule, the greater the possibility of stress that interferes with the operational performance of the pilot.

LITERATURE REVIEW

In a tight work environment such as aviation, pilots in particular often experience physical and mental pressure that causes pilots to become stressed, which stress can cause a decrease in cognitive performance. Literature and journal studies show that pilots experience a decrease in non-executive task performance after seven hours of flight, which is associated with self-report of fatigue. In addition, more than 80% of pilots said they experienced fatigue. To maintain pilot safety and performance, flight planning must consider the stress and fatigue factors of a pilot. This is because fatigue can cause depression or anxiety, which can affect the performance and work ability of a pilot as a whole (Nur Cahyanto, Taufik, Respati, H., & Natsir, M.2020).

Flight duration can significantly affect pilot performance. Flights that have a long duration, pilots will experience increased stress levels that can affect pilot performance. In research it can be shown that after about seven hours of flight duration, pilots will experience a decrease in work performance, especially in terms of non-executive tasks. Long flights can cause a decrease in the level of situational awareness, which is an important factor in safety to maintain flight safety. In addition, the relationship between stress and flight duration can cause emotional changes, such as pilots will have an increase in feelings of boredom and decreased motivation, which will affect the pilot's ability to make quick and accurate decisions (Setyawan, I., & Budiman, A. 2021).

In the scope of aviation, awareness has a significant influence in influencing pilot work performance because if the pilot no longer has awareness, the pilot will experience stress which should not happen to a pilot who is on duty in order to prevent errors in operating the aircraft which result in incidents or accidents on a flight caused by human factors. Stress caused by awareness is very important to note because it will affect the pilot's ability to understand the conditions that occur in the aircraft cockpit or the weather around them, in this case called awareness. When the level of awareness begins to decrease in this situation, it can cause an increase in stress experienced by a pilot so that it will affect their performance. Pilots who experience a decreasing or low level of awareness will potentially make errors in operating the aircraft or have poor decision making which can threaten flight safety and security (Van Leeuwen, *at all* 2013)

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METHODS

Criteria and Selection Process in Literature Review Research

A well-structured literature review forms the foundation of a strong scientific study. It synthesizes existing research, identifies gaps, and informs the direction of future inquiries. In conducting a literature review, it is crucial to establish clear criteria for selecting articles and implement a systematic approach to the selection process. This ensures that the literature analyzed is both relevant and reliable, strengthening the credibility of the research findings.

Criteria for Selecting Articles

In order to maintain the integrity and rigor of a literature review, several key criteria must be met when selecting articles:

1. **Relevance to the Research Topic** The primary criterion for selecting articles is their relevance to the study. The selected literature must align with the central theme of the research, addressing specific aspects that contribute to understanding the phenomenon in question. For instance, in the study of how stress affects pilot performance, the articles should focus on aviation psychology, cognitive load, and operational efficiency under pressure.
2. **Credibility of the Source** The validity of an article depends significantly on the credibility of the journal or publication from which it originates. Academic sources such as peer-reviewed journals, conference proceedings, and publications from reputable institutions are preferred. Sources like Google Scholar, Emerald, Springer, and institutional repositories, such as the Indonesian Aviation Polytechnic Library Curug, provide access to high-quality research.
3. **Methodological Rigor** The chosen articles must employ robust research methodologies that allow for reliable and replicable findings. Studies that clearly outline their methods, sample populations, and analytical techniques are deemed more trustworthy than those with vague descriptions or weak experimental designs. The methodological soundness ensures that the conclusions drawn from the literature review are based on well-supported evidence.
4. **Impact and Citation Frequency** The citation count and influence of an article can serve as indicators of its significance in the academic field. Highly cited papers often contribute essential theories, findings, or frameworks that shape the discipline. While new studies offer fresh perspectives, seminal papers provide foundational knowledge that guides ongoing research.
5. **Publication Date and Relevance of Findings** While classic studies provide historical context, contemporary literature is essential for staying updated with current advancements in the field. Research papers published within the last five to ten years are typically preferred, as they reflect recent developments, technological progress, and evolving industry practices.

Selection Process for Literature Review

A systematic selection process ensures that the literature review is both comprehensive and relevant. The following steps outline the methodical approach used to filter and choose articles:

1. **Identifying Relevant Sources** The first step involves gathering potential articles from various academic databases and repositories. Keywords related to the study are used to search for literature across multiple platforms, including institutional libraries and open-access journals.
2. **Preliminary Screening of Titles and Abstracts** Once articles are compiled, an initial screening process is conducted to evaluate their relevance based on titles and abstracts. This step helps eliminate irrelevant studies while focusing on those that align with the research objectives.
3. **Critical Review of Full Articles**

Selected articles undergo a comprehensive review to assess the quality of their content, research methodology, and findings. The researcher evaluates whether the studies contribute significantly to the literature review, reinforcing key arguments or addressing gaps in existing knowledge.

4. **Comparative Analysis of Studies** The next phase involves comparing the findings of various studies to identify similarities, contradictions, or emerging patterns. This analytical approach ensures that the literature review presents a balanced and well-rounded perspective on the subject.
5. **Final Selection and Categorization** The last step involves compiling the most relevant and credible articles into structured categories based on themes, variables, or research methodologies. This categorization aids in the synthesis of information, allowing for a coherent discussion in the literature review.

RESULTS AND DISCUSSION

A. Effect of stress on pilot flight performance

Stress has a very significant effect that will affect pilot flight performance, stress has various effects that are quite varied, which can be divided based on the type of stress, stress intensity, and individual response. The impact of stress that affects pilot flight performance is a problem that is significantly influenced by stress factors such as flight duration, fatigue, and awareness. Various studies have shown that stress can affect pilot performance so that it can interfere with the cognitive functions of a pilot which are important for providing a safe and comfortable flight, so that it will minimize the potential for accidents or incidents (Caldwell, J. A.2012).

1) The effect of stress on pilot decision making:
At the level of stress that is in an excessive phase or the accumulation of various stressors that are considered to be the cause of human error in this case what is meant by human is the pilot and is the biggest factor in contributing to plane crashes, this happens because the stress pressure experienced by a pilot is at the limit or maximum limit of the pilot's individual ability to face an important condition (critical phase) or in an emergency condition (emergency condition). In stressful conditions experienced by a pilot, it has the potential to cause panic or fear, and loss of self-confidence that will affect the pilot's performance if handling a job or problem will be difficult to handle or even unable to handle the problem at all, which of course can affect the safety factor of a flight (Nater, U. M. 2018).

Stress affects decision making based on research results, it was shown that stressful conditions greatly affect decision making where the sympathetic nerves quickly respond to nongenomic mechanisms quickly. Decision making often occurs in stressful situations, where this study focuses on risky conditions.

Because stress can affect a pilot's cognitive abilities, increased stress levels can reduce their ability to make quick decisions. Pilots often experience automatic responses such as panic or mental tension when in high-stress situations, which causes them to lose a lot of time to think. This prevents them from considering the situation objectively and thoroughly. Excessive stress can cause pilots to be irrational when making decisions because they tend to concentrate on one particular problem or solution without considering alternatives or the broader consequences of their actions. Ultimately, errors that can compromise flight safety can occur due to this reduced ability to analyze the situation (Venus, M., *at all* 2022).

When the psychology of the pilot increases significantly, it will have an impact on the pilot's ability to make decisions quickly and accurately will potentially experience a significant decline. Which results in the pilot being more likely to experience sudden panic reactions or even being in a mindset or in a narrow way of thinking so that a pilot cannot make decisions quickly and accurately.

Under these conditions, the nervous system and cognitive functions do not function properly. As a result, even though there are many choices, the pilot may not be able to choose the best one due to limitations in accessing and processing information. Overall, increased stress reduces decision-making ability, which can ultimately compromise flight safety (Young, R. D. 2008).

Stress will result in inhibiting brain function, namely working memory and concentration. When a pilot experiences stress, the brain's capacity to process the information received will decrease which has the potential to cause errors in aircraft operations, be it in navigation, communication, or pilot response when facing

important situations (critical phase) or in emergency situations (emergency condition) so that the pilot's performance will decrease which will directly impact flight safety and security (Cahill, J., Cullen, P., Anwer, S., Wilson, S., & Gaynor, K.2021).

The effect of stress on pilot flight performance certainly has a great influence on pilot performance. Some types of stress include stress caused by fatigue, stress caused by flight duration, and stress caused by awareness of the pilot himself, as well as many other types of stress, in this discussion will focus on these three causes (Zhao, Y. *at a*ll, 2023)

2) The effect of stress due to fatigue on pilot performance.

Fatigue is one of the causes of stress that occurs in pilots.

Fatigue triggers occur when pilots do not get enough rest, getting a high workload can also have an impact on a pilot's fatigue, or in operational conditions that require pilots to work beyond the established limitations. In this fatigue condition, the body and mind will not be able to work optimally, so that it will have an impact on reducing physical and mental capacity. Which can cause the nervous system to release stress hormones such as cortisol, which will trigger stress and affect various body functions (Boksem, M. A. S., & Tops, M.2008).

When viewed from a cognitive perspective, fatigue has an effect on decreasing the level of working memory and concentration and affects decision making which can affect the safety factor (Hsberg, E. A. Ê. 2000).

Stress caused by fatigue will have an impact on reducing the pilot's working memory and concentration. Which will have an impact on the process of processing information received by the pilot to be slow, so that the pilot will have difficulty realizing the flight situation that occurs quickly and accurately. Errors in reading instruments or ignoring critical alarms (warning alerts) on the aircraft can occur due to limited cognitive capacity (Fiedler, E. R., P. Della Rocco, D. J. Schroeder, and K. T. Nguyen. 2000).

The impact of stress caused by fatigue also affects decision making in pilots, because when the pilot experiences fatigue, the pilot will tend to experience (decision paralysis), where the process of processing and evaluating the information received and the actions taken by the pilot are hampered or even stopped. In conditions like this, it is certainly very dangerous, especially in emergency situations that require the pilot to make decisions quickly and accurately (Enoka, R. M., & Duchateau, J. 2008)

Pilot performance is greatly affected by stress caused by fatigue. Pilots in both commercial and military aviation often experience high levels of physical and mental stress, which can reduce cognitive performance. Studies have shown that after a seven-hour flight, pilots report a decline in non-executive task performance, and this is related to their self-report of fatigue (Rosekind, M. R. *at all*, 1994*)*

Based on the results of the study, it also shows that more than 80% of pilots also said that fatigue would have an impact and influence their flight performance, so that many admitted that they had made mistakes in operations or in decision making due to fatigue, which had an impact on the safety factor of the flight (Xiao, 2005)

To maintain the performance of the pilot, the flight planning must consider the fatigue and stress factors. Therefore, it will cause feelings of depression or anxiety that affect the performance of the pilot's overall performance, so it is very important to pay attention to the stress factor due to fatigue in a flight planning as an effort to avoid incidents or accidents (Wibawanti, R. *at all*, 2021)

3) The effect of stress due to flight duration on pilot performance.

Long flight duration will directly impact the increase in stress experienced by a pilot. The longer the flight time, the more it will affect the physical and mental burden of the pilot, if it occurs continuously it will accumulate. If this accumulation of stress occurs continuously, it will cause the body and brain to not get enough time to recover, so that it will affect the pilot's performance in stressful conditions due to long flight duration.

In the research that has been conducted, the research revealed that pilots will experience increased stress which results in decreased performance after about 7 hours of flight. However, it highlights that cognitive function at a high level causes pilot performance to decrease compared to pilots who fly for a shorter duration.

The more important impact of flight duration is that it can reduce and reduce the working memory capacity of a pilot, which causes the pilot to experience a decrease in responding to an

incident or phenomenon that occurs during the flight, so that flights with long durations (long flight duration) can reduce the performance of the pilot. So that flight planning, including loading flight crew on flights is very important to consider, by paying attention to flight duration, it is necessary to pay attention to the composition of the flight crew, especially the pilot, whether additional personnel are needed on flights with long durations (long flight duration), because this includes the safety of a flight, as a form of effort to reduce the potential for operational errors and avoid accidents or incidents caused by human factors (Phillips, R. O.2021).

In the research journal it can be shown that flights lasting between 7.5 to 9.5 hours have the potential to cause disruption to the pilot's cognitive performance. Which means that the pilot when flying the plane for a period of between 7.5 to 9.5 hours affects the pilot's performance to process information both on the aircraft instrument and instructions given by the Air Traffic Controller (ATC), which results in a decrease in cognitive performance that can increase the risk of errors in aircraft operations, especially when the aircraft is in an emergency.

4) The effect of stress due to awareness on pilot performance.

Situational awareness is a factor that must be possessed by a pilot because situational awareness is the ability of a pilot to collect, understand information, and interpret information received while flying or information contained in aircraft instruments including communication with Air Traffic Controller (ATC), or external conditions during flight such as weather (International Civil Aviation Organization 2019).

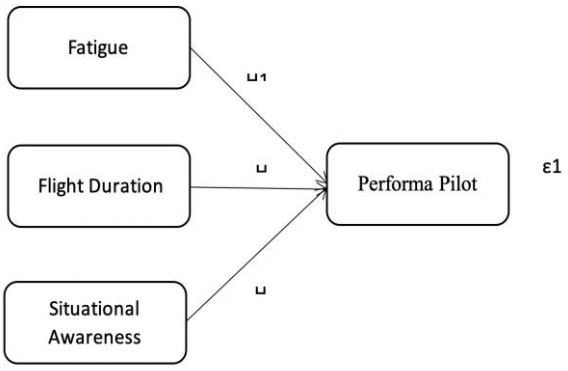
Situational Awareness with high quality will directly correlate with the improvement of pilot performance and performance. Which can be interpreted that pilots who have a high level of situational awareness will have good control of the situation, so that in operating the aircraft the pilot has decision making or taking decisions quickly and accurately, so that it correlates with the increasing level of security and safety of flight operations and minimizes the occurrence of accidents or incidents in flight (Keinan, G. 1987).

The quality of information and experience factors of the pilot are factors that influence the level of situational awareness of a pilot. The influence of accurate and timely information, and if integrated with experience, will help the pilot to better understand the surrounding conditions (situational awareness) in flight conditions and have an impact on decision making that is appropriate quickly and accurately. In conditions of complex tasks or excessive workload conditions, there is a possibility of dissociation between mental workload, and pilot performance or performance, and awareness while on duty, which means that even though the pilot has good situational awareness, excessive workload or tasks that are too complex can cause a decrease in the level of situational awareness and will experience a mismatch with what is experienced or the workload faced which will have an impact on pilot performance. With these factors, when assessing pilot performance and performance, factors such as mental workload, workload, and situational awareness must be considered holistically (F. A. Mendonca, M. Suckow, and B. G. Dillman. 2019).

In the research that has been done, that situational awareness is a vital component in pilot performance and performance. At this time there are techniques and tools as a design to improve situational awareness that can improve situational awareness to reduce the risk of operational errors in aircraft or in decision making, especially in emergency situations or quite complex tasks. Therefore, workload management is needed, as well as improving the quality of information received by pilots, and improving the aircraft operation training system, and experience is very important to ensure that pilots maintain an optimal level of situational awareness during the flight. Overall, it can be explained that situational awareness is a key factor that not only affects the cognitive abilities of the pilot, but will have a direct impact on flight safety and security (Mayo, A.2000).

Tabel 1.1: Relevant Research

No.	Author (Year)	Previous research results	Similarities with this article	Differences with this article
1	Bendak, S., & Rashid, H. S. J. (2020)	Stress and fatigue have an influence on flight safety	Stress and fatigue have an influence on flight safety	The Effect of Stress Due to Fatigue, Flight Duration, and Situation Awareness on Pilot Flight Performance
2	Zhao, Y., Wang, Y., Guo, W., Cheng, L., Tong, J., Ji, R., Zhou, Y., Liu, Z., & Wang, L. (2023).	Fatigue is a major factor in reducing pilot performance, impacting flight safety.	Fatigue reduces pilot performance	The Effect of Stress Due to Fatigue, Flight Duration, and Situation Awareness on Pilot Flight Performance
3	International Civil Aviation Organisation (2020)	Long flight hours will affect the pilot's work	Long flight hours will affect the pilot's work	The Effect of Stress Due to Fatigue, Flight Duration, and Situation Awareness on Pilot Flight Performance
.4	Cahill, J., Cullen, P., Anwer, S., Wilson, S., & Gaynor, K. (2021).	Job stress can affect flight safety	Work stress can affect pilot decision making, which has an impact on flight safety.	Flight Duration, and Situation Awareness on Pilot Flight Performance
.5	Wojcik, D. Z., C. J. A. Moulin, and A. Fernandez. (2021)	Pilot stress affects flight safety.	Pilot performance is affected by stress	The Effect of Stress Due to Fatigue, Flight Duration, and Situation Awareness on Pilot Flight Performance
6	Young, M., and N. Stanton. 2002	Job stress can affect flight safety.	Pilot performance is affected by stress	Situation Awareness on Pilot Flight Performance



Picture 1.1 : Conceptual Framework

Based on the conceptual framework image, it can be seen that fatigue, flight duration, and situational awareness all of these variables have an influence on pilot performance.

CONCLUSION

Stress due to fatigue has a very significant impact on pilot performance. Decreased cognitive function, impaired decision-making, and decreased operational skills are factors that can threaten flight safety. Therefore, fatigue management and stress management training are the main keys to maintaining optimal performance and safety in flight operations.

Flight Duration or flight duration, especially long flight duration, has an effect on increasing fatigue and excessive stress levels which have a significant impact on pilot performance. If there is a disturbance in cognitive function, as well as motor coordination, and situational awareness, it will directly increase the risk of operational errors in flights so that it can threaten flight safety. The importance of implementing policies in managing fatigue and strategies in proper mitigation is very important in order to maintain optimal pilot performance during long-duration flights (International Civil Aviation Organisation 2020).

The impact of stress caused by situational awareness has a negative impact because it can significantly affect pilot performance and performance. In more detail, pilots who are tired and do not have situational awareness will be able to inhibit working memory function, even narrow the focus of attention, and will reduce decision making, which has an impact on the pilot's ability to respond and anticipate in flight situations, thus increasing the potential for aircraft accidents, both accidents and incidents.

SUGGESTIONS

Based on the conclusion above that fatigue, flight duration, and situational awareness are obtained the following suggestions:

1. Efforts to avoid fatigue in pilots when carrying out their duties are to recognize the conditions before carrying out the flight, if you have felt fatigue, you can convey to the chief pilot or related division not to continue the flight so that it can create a preventive form in an effort to prevent aircraft accidents caused by human factors from fatigued pilots.

2. Long flight duration causes pilots to lose focus and can affect flight safety, so the mitigation efforts are to ensure that rest hours have been met, and ensure that the nutrition received is sufficient so that it will increase focus when flying.

3. To increase the level of situational awareness, sufficient focus is needed but not to the level of stress, with good time management and operations will increase the level of situational awareness in pilots when flying.

From the suggestions above, it is an effort to reduce the potential for aircraft accidents, which are caused by human factors, so that it will create flight safety and security.

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