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Analysis of Psychological Conditions and Cognitive Load after Aircraft Accident/Incident on Air Traffic Controller Situational Awareness

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A B S T R A C T

This study analyzes the effect of psychological conditions and cognitive load after aircraft accident/incident on situational awareness among Air Traffic Controllers at AirNav Indonesia Surabaya Branch. Using a quantitative survey design, data were collected from 60 respondents through Likert-scale questionnaires and analyzed using validity, reliability, correlation, classical assumption, multiple regression, t-test, F-test, and determination coefficient procedures. The results show that psychological conditions and cognitive load were moderate, while situational awareness was high. Both variables had no significant partial or simultaneous effect on situational awareness. These findings indicate that controller situational awareness may be more strongly shaped by experience, training, procedures, technology, organizational support, and safety culture.

INTRODUCTION

Aviation safety is one of the most important aspects of air transportation because it is directly related to human life, operational continuity, and public trust in the aviation system. In this system, Air Traffic Controllers have a strategic role in maintaining aircraft separation, ensuring orderly air traffic flow, and providing information needed to support safe flight operations. Air traffic services are designed to prevent collisions, maintain the regular movement of aircraft, and provide information required for safe and efficient flight operations (International Civil Aviation Organization, 2018). Therefore, the quality of Air Traffic Controller performance is closely related to the overall quality of aviation safety.

The work of Air Traffic Controllers requires a high level of attention, accuracy, and decision-making ability. Controllers must monitor aircraft movement, process visual and auditory information, communicate with pilots, coordinate with other units, and respond to unexpected changes in air traffic conditions. This situation makes the profession closely related to cognitive workload and occupational stress because controllers must remain vigilant while working under time pressure (Seftiyana, 2021). In this context, situational awareness becomes a core capability because it allows controllers to perceive operational conditions, understand their meaning, and anticipate future traffic development.

Situational awareness is especially important in air traffic control because operational conditions can change rapidly. Endsley (1995) explains that situational awareness consists of three major levels, namely perception, comprehension, and projection. In the context of air traffic control, this means that controllers must first detect relevant elements in the operational environment, understand the meaning of those elements, and predict how the situation may develop. This ability supports decision-making, conflict detection, and safe operational response in dynamic air traffic situations.

The importance of situational awareness becomes more critical when controllers are involved in aircraft accident or incident situations. An aircraft accident or incident is not only a technical or procedural event, but also a psychological experience that may cause pressure, anxiety, guilt, and trauma for personnel involved in the control process. Eurocontrol (2020) explains that exposure to critical incidents can trigger critical incident stress among aviation personnel. Similarly, Saputra et al. (2022) show that post-accident or post-incident situations may increase cognitive workload among Air Traffic Controllers.

The Indonesian aviation context also demonstrates the need to examine human factors in air traffic control. The research notes show that more than 140 aviation events were recorded in Indonesia during 2004–2024, with the 2007–2016 period identified as a critical phase. These events show that aviation safety is not only influenced by aircraft technology, navigation facilities, and operational procedures, but also by the psychological readiness and cognitive capacity of personnel who manage air traffic operations. Therefore, psychological conditions

and cognitive load after aircraft accident/incident need to be studied in relation to situational awareness.

Previous studies have shown that trauma and cognitive load may affect human performance in high-risk work environments. Brindley and Tse (2016) state that psychological pressure and high task demands can interfere with cognitive performance. Utami et al. (2022) also emphasize that cognitive workload can reduce the ability to maintain mental representation of dynamic situations. However, empirical research that specifically examines the effect of post-aircraft accident/incident psychological conditions and cognitive load on Air Traffic Controller situational awareness in Indonesia is still limited.

Based on this gap, this study aims to analyze the effect of psychological conditions and cognitive load after aircraft accident/incident on the situational awareness capability of Air Traffic Controllers at AirNav Indonesia Surabaya Branch. This study contributes theoretically to the development of aviation psychology, human factors, and air traffic control performance studies. Practically, this study provides input for air navigation service providers in strengthening post-incident psychological support, workload management, and operational readiness programs for Air Traffic Controllers.

LITERATURE REVIEW

Air Traffic Controller

Air Traffic Controller is a key profession in the aviation safety system because it directly supports aircraft separation and traffic flow management. Air Traffic Controllers are responsible for preventing collisions between aircraft and between aircraft and obstacles in operational areas (Susanto et al., 2020). Air traffic control service also becomes an important instrument in ensuring navigation continuity and flight safety standards (Prasetyo & Budiawan, 2019). This role shows that Air Traffic Controllers work as a central element in the operational safety chain.

The work of Air Traffic Controllers includes several service domains, such as area control service, approach control service, and aerodrome control service. These domains require controllers to manage different phases of flight, including en-route movement, arrival, departure, and aircraft movement around the airport area. Because the operational environment is dynamic, controllers need strong cognitive ability, especially in processing visual and auditory information and making decisions under time pressure (Button & Neiva, 2014). This explains why psychological stability and cognitive readiness are important for controller performance.

Aircraft Accident and Incident

Aircraft accident and incident are two important concepts in aviation safety. An accident usually refers to an event that causes fatal or serious injury, significant aircraft damage, or missing aircraft. Meanwhile, an incident refers to an event that may not directly cause damage or loss, but has the potential to affect operational safety. The International Civil Aviation Organization (2016)

distinguishes accident and incident based on their level of consequence and safety impact.

In the operational context, incidents may include near-miss events or hazardous occurrences that have the potential to develop into accidents if they are not properly managed. Poerwanto and Mauidzoh (2016) explain that incidents can be understood as near-miss events that indicate safety system weaknesses. For Air Traffic Controllers, such events may create psychological pressure because controllers are directly involved in decision-making and traffic management during critical situations. Thus, accident and incident experiences can become stressors that affect both emotional and cognitive conditions.

Situational Awareness

Situational awareness is a major concept in dynamic and high-risk work systems. Endsley (1995) defines situational awareness as the perception of elements in the environment, the comprehension of their meaning, and the projection of their status in the future. In air traffic control, situational awareness allows controllers to identify aircraft position, understand traffic configuration, anticipate possible conflicts, and make accurate decisions in a short time.

Situational awareness in the Air Traffic Control domain depends on the ability to continuously update information and build an accurate mental model of the traffic situation. Samardžić et al. (2022) state that situational awareness in air traffic control includes perception, comprehension, and projection that support operational decision-making. Kraemer and Süß (2015) also explain that situational awareness is related to working memory because individuals must process external information and transform it into an internal representation of the current situation.

Psychological Conditions after Aircraft Accident/Incident

Psychological condition in this study refers to trauma or emotional disturbance experienced after aircraft accident/incident. Trauma can occur when an individual faces a sudden, threatening, or emotionally disturbing event. Hatta (2016) explains that trauma may leave a deep psychological impression and disturb physical and psychological stability. In the aviation context, accident or incident exposure may produce emotional reactions, anxiety, sleep disturbance, repeated memories, physiological responses, and social or occupational disturbance.

The American Psychiatric Association (2013) explains that trauma symptoms may include emotional reactions, repeated traumatic experiences, behavioral changes, physiological responses, and disturbance in social functioning. These symptoms are relevant in the Air Traffic Controller context because controllers must maintain concentration and decision-making ability even after experiencing critical operational events. Therefore, psychological condition is an important variable in understanding controller readiness after an accident or incident.

H1: Psychological conditions after aircraft accident/incident have a significant effect on the situational awareness capability of Air Traffic Controllers at AirNav Indonesia Surabaya Branch.

Cognitive Load

Cognitive load refers to the mental demand experienced by individuals when they process information, maintain attention, manage time pressure, and make decisions in complex tasks. Hart and Staveland (1988) explain that workload can be understood through several dimensions, including mental demand, temporal demand, performance, effort, and frustration. In air traffic control, cognitive load arises from task quantity, information volume, task complexity, uncertainty, time pressure, and responsibility for operational decisions.

Excessive cognitive load may reduce attention, memory performance, response speed, and decision accuracy. Pradhana and Prastawa (2022) state that cognitive work design that is not properly managed can lead to mental fatigue, reduced vigilance, and degradation of situational awareness. Sari and Suliantoro (2021) also explain that high cognitive load can produce physiological, psychological, and behavioral symptoms. Based on this theoretical relationship, cognitive load is expected to influence situational awareness in high-risk operational environments.

H2: Cognitive load after aircraft accident/incident has a significant effect on the situational awareness capability of Air Traffic Controllers at AirNav Indonesia Surabaya Branch.

The relationship between psychological conditions and cognitive load is also important because trauma may increase mental effort and reduce cognitive capacity. When controllers experience psychological pressure and cognitive demand at the same time, situational awareness may be affected. Therefore, this study also tests the simultaneous effect of psychological conditions and cognitive load on situational awareness.

H3: Psychological conditions and cognitive load after aircraft accident/incident simultaneously have a significant effect on the situational awareness capability of Air Traffic Controllers at AirNav Indonesia Surabaya Branch.

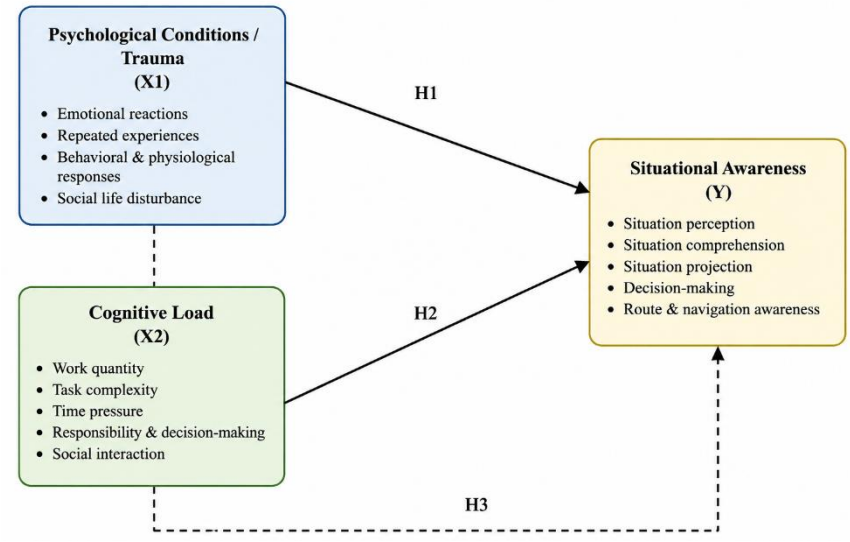

Figure 1. Conceptual Framework

METHODOLOGY

Research Design

This study used a quantitative survey approach. This approach was selected because the research aimed to measure the effect of psychological conditions and cognitive load on situational awareness through numerical data and statistical testing. Survey research is appropriate for collecting data about opinions, perceptions, characteristics, and behavior from respondents through structured questions (Sugiyono, 2017). In this study, the survey was used to obtain responses from Air Traffic Controllers regarding their psychological conditions, perceived cognitive load, and situational awareness after aircraft accident/incident.

Population and Sample

The population of this study consisted of all Air Traffic Controllers at AirNav Indonesia Surabaya Branch who were officially registered in 2026. The total population was 77 personnel. The sample was selected using purposive sampling because this study required respondents who had direct experience or operational relevance to aircraft accident or incident situations. Based on the collected data, 60 respondents were analyzed in this study. The use of purposive sampling allowed the researcher to focus on participants who understood the phenomenon being examined.

Research Instrument

The data were collected using a structured questionnaire with a five-point Likert scale. The response categories consisted of strongly agree, agree, neutral, disagree, and strongly disagree. The psychological condition variable consisted of 10 statement items covering emotional reactions, repeated experiences, behavioral and physiological responses, and social life disturbance. The cognitive load variable consisted of 10 statement items covering work quantity, work quality, time pressure, responsibility and decision-making, and social interaction. The situational awareness variable consisted of 10 statement items covering situation perception, situation comprehension, situation projection, decision-making, and route and navigation awareness.

Data Analysis Technique

The data analysis process included descriptive statistics, validity testing, reliability testing, correlation analysis, classical assumption testing, multiple linear regression, t-test, F-test, and coefficient of determination. Validity testing was used to examine whether each questionnaire item was able to measure the intended variable. Reliability testing was used to examine the internal consistency of the instrument (Sujarweni, 2019). Classical assumption testing included normality, multicollinearity, and heteroscedasticity tests. Multiple linear regression was used to test the effect of the independent variables on the dependent variable.

The regression equation used in this study was:

$$\mathbf{Y = \alpha + \beta 1X1 + \beta 2X2 + e} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where Y refers to situational awareness, X1 refers to psychological conditions or trauma, X2 refers to cognitive load, α refers to the constant, β refers to the regression coefficient, and e refers to the standard error. The t-test was used to examine the partial effect of each independent variable, while the F-test was used to examine the simultaneous effect of psychological conditions and cognitive load on situational awareness (Ghozali, 2018).

RESEARCH RESULTS

Respondent Characteristics

The study involved 60 Air Traffic Controllers at AirNav Indonesia Surabaya Branch. The respondents consisted of 35 male respondents or 58.3% and 25 female respondents or 41.7%. This indicates that male respondents were dominant, but female respondents were also represented in the sample. Based on age, the largest group was respondents aged 46 years and above, consisting of 25 respondents or 41.7%. The second largest group was respondents aged 36–40 years, consisting of 23 respondents or 38.3%. Based on work experience, most respondents had long professional experience. Respondents with 21 years or more of work experience reached 25 people or 41.7%, while respondents with 11–15 years of work experience reached 23 people or 38.3%.

Table 1. Respondent Characteristics

Characteristics	Dominant Category	Frequency	Percentage
Gender	Male	35	58.3%
Age	≥ 46 years	25	41.7%
Work experience	≥ 21 years	25	41.7%

The characteristics show that most respondents were mature and experienced Air Traffic Controllers. This condition is important because professional experience may influence how controllers manage psychological pressure, cognitive demands, and situational awareness in operational settings.

Descriptive Statistical Results

The descriptive statistical results show that psychological conditions or trauma had a mean score of 3.05, a standard deviation of 0.81, a minimum value of 1.20, and a maximum value of 4.30. This variable was categorized as moderate. Cognitive load also had a mean score of 3.05, a standard deviation of 0.85, a minimum value of 1.40, and a maximum value of 5.00. This variable was also categorized as moderate. Meanwhile, situational awareness had a mean score of 4.15, a standard deviation of 0.48, a minimum value of 3.10, and a maximum value of 5.00. This variable was categorized as high.

Table 2. Descriptive Statistics of Research Variables

Variable	Mean	Standard Deviation	Minimum	Maximum	Category
Psychological Conditions / Trauma (X1)	3.05	0.81	1.20	4.30	Moderate

Cognitive Load (X2)	3.05	0.85	1.40	5.00	Moderate
Situational Awareness (Y)	4.15	0.48	3.10	5.00	High

These results indicate that the respondents experienced moderate psychological conditions and cognitive load after aircraft accident/incident, while their situational awareness remained high. This means that the controllers were still able to maintain perception, comprehension, projection, and decision-making capabilities in their operational duties.

Validity and Reliability Test

The validity test showed that all items in the psychological condition, cognitive load, and situational awareness variables were valid. The lowest item-total correlation value in the psychological condition variable was 0.538. The lowest value in the cognitive load variable was 0.514, while the lowest value in the situational awareness variable was 0.654. All values were higher than the minimum criterion of 0.30.

Table 3. Summary of Validity Test

Variable	Number of Items	Lowest Item-Total Correlation	Result
Psychological Conditions / Trauma (X1)	10	0.538	Valid
Cognitive Load (X2)	10	0.514	Valid
Situational Awareness (Y)	10	0.654	Valid

The reliability test showed that all variables had strong internal consistency. The Cronbach's Alpha value for psychological conditions was 0.918, cognitive load was 0.923, and situational awareness was 0.941. These values were higher than the minimum reliability criterion of 0.60.

Table 4. Reliability Test Results

Variable	Cronbach's Alpha	Result
Psychological Conditions / Trauma (X1)	0.918	Highly Reliable
Cognitive Load (X2)	0.923	Highly Reliable
Situational Awareness (Y)	0.941	Highly Reliable

These findings show that the research instrument was valid and reliable. Therefore, the data were appropriate for further statistical analysis.

Correlation Analysis

The correlation test showed that the relationship between psychological conditions and situational awareness had a coefficient of -0.156 with a significance value of 0.235. This indicates a weak negative and insignificant relationship. The relationship between cognitive load and situational awareness had a coefficient of -0.034 with a significance value of 0.796. This indicates a very

weak negative and insignificant relationship. Meanwhile, the relationship between psychological conditions and cognitive load had a coefficient of 0.698 with a significance value of 0.000, indicating a strong positive and significant relationship.

Table 5. Correlation Test Results

Variable Relationship	Correlation Coefficient	Sig.	Result
X1 and Y	-0.156	0.235	Not Significant
X2 and Y	-0.034	0.796	Not Significant
X1 and X2	0.698	0.000	Significant

These results show that psychological conditions and cognitive load were strongly related to each other. However, each variable did not show a significant relationship with situational awareness.

Classical Assumption Test

The normality test using Kolmogorov-Smirnov produced a significance value of 0.037. Because this value was lower than 0.05, the residuals were not normally distributed. The multicollinearity test showed that the VIF value for psychological conditions and cognitive load was 1.951. Because the value was lower than 10, the regression model did not indicate multicollinearity. The heteroscedasticity test produced a significance value of 0.562. Because this value was higher than 0.05, the model did not indicate heteroscedasticity.

Table 6. Classical Assumption Test Results

Test	Value	Result
Kolmogorov-Smirnov Normality Test	Sig. 0.037	Not Normal
Multicollinearity Test X1	VIF 1.951	No Multicollinearity
Multicollinearity Test X2	VIF 1.951	No Multicollinearity
Heteroscedasticity Test	Sig. 0.562	No Heteroscedasticity

Although the residuals were not normally distributed, the regression analysis was still presented as an overview of the relationship among variables. However, the interpretation of the regression results should be made carefully.

Multiple Linear Regression Test

The multiple linear regression analysis produced the following equation:

$$\mathbf{Y = 4.369 - 0.155X1 + 0.083X2} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

The coefficient of psychological conditions was -0.155. This indicates a negative direction between psychological conditions and situational awareness. However, the significance value was 0.162, which was higher than 0.05. Therefore, psychological conditions did not significantly affect situational awareness. The coefficient of cognitive load was 0.083. This indicates a small positive direction between cognitive load and situational awareness. However, the significance value was 0.427, which was higher than 0.05. Therefore, cognitive load also did not significantly affect situational awareness.

Table 7. Multiple Linear Regression Results

Variable	Coefficient B	t-count	Sig.	Result
Constant	4.369	16.785	0.000	Significant
Psychological Conditions / Trauma (X1)	-0.155	-1.416	0.162	Not Significant
Cognitive Load (X2)	0.083	0.800	0.427	Not Significant

Based on these results, H1 and H2 were rejected. Psychological conditions and cognitive load did not have a significant partial effect on the situational awareness capability of Air Traffic Controllers at AirNav Indonesia Surabaya Branch.

Simultaneous Test and Coefficient of Determination

The F-test produced an F-count value of 1.037 with a significance value of 0.361. Because the significance value was higher than 0.05, psychological conditions and cognitive load simultaneously did not have a significant effect on situational awareness.

Table 8. F-Test Result

Model	F-count	Sig.	Result
Regression	1.037	0.361	Not Significant

The coefficient of determination showed an R Square value of 0.035 and an Adjusted R Square value of 0.001. This means that psychological conditions and cognitive load explained only 3.5% of the variation in situational awareness. The remaining 96.5% was explained by other factors outside the model.

Table 9. Coefficient of Determination

R Square	Adjusted R Square	Interpretation
0.035	0.001	Very Low Contribution

These results show that H3 was rejected. Psychological conditions and cognitive load did not simultaneously affect situational awareness in a statistically significant way.

The findings of this study show that psychological conditions or trauma after aircraft accident/incident did not significantly affect the situational awareness capability of Air Traffic Controllers at AirNav Indonesia Surabaya Branch. Although the regression coefficient showed a negative direction, the effect was not statistically significant. This means that higher psychological pressure tended to be followed by lower situational awareness, but the tendency was not strong enough to be proven statistically in this research model. This result does not mean that psychological conditions are unimportant. Instead, it shows that in this sample, psychological conditions alone were not sufficient to explain differences in situational awareness.

One possible explanation is the high level of professional experience among respondents. Most respondents had worked for more than 11 years, and the largest

group had worked for 21 years or more. This long experience may help controllers build strong mental models, procedural familiarity, emotional control, and adaptive strategies in dealing with operational pressure. Samardžić et al. (2022) explain that situational awareness in air traffic control depends on the ability to update information, use experience, and construct an accurate mental model of traffic dynamics. Therefore, experience may function as a protective factor that helps controllers maintain situational awareness even when they experience psychological pressure.

The findings also show that cognitive load did not significantly affect situational awareness. This result is different from theoretical expectations that high cognitive load may reduce attention, memory, and decision-making performance. Hart and Staveland (1988) explain that workload includes mental demand, time pressure, effort, performance, and frustration. Pradhana and Prastawa (2022) also argue that excessive cognitive workload can reduce vigilance and situational awareness. However, in this study, the cognitive load experienced by respondents was only in the moderate category. This condition may explain why cognitive load did not significantly reduce situational awareness.

The simultaneous test also showed that psychological conditions and cognitive load did not significantly affect situational awareness. The R Square value of 3.5% indicates that the model had very low explanatory power. This finding confirms that situational awareness is a complex capability that cannot be explained only by psychological conditions and cognitive load. Endsley (1995) states that situational awareness involves perception, comprehension, and projection in dynamic systems. In air traffic control, this process may also be influenced by training, technical competence, communication, teamwork, interface design, standard operating procedures, traffic complexity, and safety culture.

The strong positive correlation between psychological conditions and cognitive load is still an important finding. It shows that controllers who experience higher psychological pressure also tend to experience higher cognitive load. This finding is consistent with the argument that critical events can increase mental workload and emotional burden. Saputra et al. (2022) found that post-accident or post-incident situations can influence cognitive workload among Air Traffic Controllers. Similarly, Eurocontrol (2020) emphasizes that critical incident stress management is important for helping aviation personnel recover from critical operational events.

From a practical perspective, the findings suggest that AirNav Indonesia Surabaya Branch should not ignore psychological conditions and cognitive load even though their effects were not statistically significant in this study. Aviation safety depends on the continuity of human performance, especially in high-risk work environments. Therefore, post-incident psychological support, workload monitoring, fatigue management, and scenario-based training are still necessary. Čekanová et al. (2016) explain that Air Traffic Controllers who experience critical incidents may need psychological support before returning to normal operational duties.

The novelty of this study lies in its focus on the relationship between post-aircraft accident/incident psychological conditions, cognitive load, and situational awareness in the AirNav Indonesia Surabaya Branch context. Previous studies have discussed workload, stress, and situational awareness separately, but this study combines them in a post-incident operational framework. The finding that both independent variables did not significantly affect situational awareness provides an important insight that experienced controllers may maintain high situational awareness despite moderate psychological and cognitive pressure. This expands the understanding of human factors in air traffic control by showing the possible role of experience and operational adaptation.

However, this study has several limitations. The first limitation is the number of respondents, which was limited to 60 Air Traffic Controllers from one branch. The second limitation is the use of self-report questionnaires, which may be influenced by respondent subjectivity. The third limitation is that the residuals were not normally distributed, so the regression results should be interpreted carefully. The fourth limitation is that the study only included psychological conditions and cognitive load as independent variables, while the determination coefficient showed that most variation in situational awareness was explained by other factors outside the model.

CONCLUSION AND RECOMMENDATION

This study confirms that psychological conditions after aircraft accident/incident did not have a significant effect on the situational awareness capability of Air Traffic Controllers at AirNav Indonesia Surabaya Branch. Cognitive load also did not have a significant effect on situational awareness. Simultaneously, psychological conditions and cognitive load did not significantly influence situational awareness. The coefficient of determination showed that both variables explained only a small part of situational awareness variation, while most variation was influenced by other factors outside the model. These findings indicate that situational awareness among Air Traffic Controllers is a complex capability that may be more strongly shaped by work experience, training, technical competence, operating procedures, technology, teamwork, organizational support, and safety culture. Therefore, AirNav Indonesia Surabaya Branch is recommended to strengthen post-incident psychological assistance, workload monitoring, fatigue management, scenario-based training, and human factor programs to maintain controller readiness and aviation safety.

FURTHER STUDY

This study has limitations in sample size, research location, measurement method, and variable coverage. Further research is recommended to involve more AirNav branches in Indonesia so that the findings can be generalized more widely. Future studies should also use a mixed-method approach by combining questionnaires, interviews, observations, and operational performance data. In addition, further research should include other variables such as resilience, fatigue, communication quality, teamwork, training intensity, safety culture, system interface quality, and organizational support. These variables may

provide a more comprehensive explanation of situational awareness among Air Traffic Controllers after aircraft accident or incident situations.

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