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Analysis of Workplace Facilities Influence on ATC Performance at AirNav Jakarta ACC Unit

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Abstract
This study aims to analyze the influence of workplace facilities on the performance of Air Traffic Controllers (ATC) at the Area Control Centre Unit of AirNav, Jakarta Air Traffic Service Centre (JATSC). Facilities such as communication systems, radar displays, and supporting infrastructure are critical to aviation safety and operational efficiency. Issues like illegal radio signals, frequency interference, and radar shadowing can disrupt communication and reduce ATC performance. The research employs a quantitative approach with a positivist paradigm to obtain objective, numerical data. From a population of 238 ATC personnel, 79 respondents were selected using simple random sampling based on Slovin's formula. Data collection methods included questionnaires, documentation, and secondary data. Data analysis was conducted using statistical software through stages of data cleaning, variable coding, descriptive analysis, and correlation testing using Pearson or Spearman methods. The questionnaire assessed ATC perceptions of workplace facilities, while documentation and secondary data provided contextual support. The findings are expected to contribute theoretically to human resource and occupational safety literature, and practically support AirNav Indonesia in evaluating and improving workplace facilities to enhance air traffic control performance and aviation safety

Keywords: Workplace Facilities, Performance, Air Traffic Controller, Area Control Centre

INTRODUCTION

The performance of Air Traffic Controllers (ATC) plays a crucial role in ensuring the smoothness and safety of air navigation operations. This performance is not solely determined by individual competence but is also significantly influenced by the availability and adequacy of workplace facilities. In this context, workplace facilities can be categorized into two main dimensions: (1) machines and equipment, and (2) physical infrastructure. Machines and equipment include operational support systems such as communication systems, radar, and coordination devices between units, while physical infrastructure encompasses ergonomic workspace design, proper lighting, rest areas, temperature, and noise control. Both dimensions work simultaneously to affect ATC performance (Robbins & Judge, 2017; ICAO, 2016).

In the ATC environment, reliable workplace facilities are essential for maintaining coordination, ensuring rapid decision-making, and guaranteeing information accuracy. According to human resource management theory, adequate facilities enhance comfort, concentration, and productivity, while poor facilities may cause operational disturbances, reduce motivation, and degrade performance levels. This is particularly critical for ATCs, whose work environment involves high pressure, human-life responsibilities, and the need for accuracy and speed.

Jakarta Air Traffic Service Centre (JATSC), managed by AirNav Indonesia, is one of the busiest and most complex air traffic control centers in Southeast Asia. ATCs at this facility manage high traffic volumes that require advanced communication and radar systems. However, several operational challenges have occurred, including illegal radio signal interference (2018), near-miss incidents due to communication issues (2017), and environmental disruptions like kite flying near airports, all of which demonstrate the importance of reliable facilities in maintaining operational safety (Ulandari & Dyahjatmayanti, 2022; ICAO, 2016).

Additionally, ICAO's *Human Factors Manual* (Doc 9683) emphasizes the importance of the physical work environment such as lighting, temperature, ergonomics, and noise as critical elements of safety and performance. The SHEL Model (Software, Hardware, Environment, Liveware) provides a conceptual framework for evaluating human performance within aviation systems, particularly the Liveware Hardware and Liveware Environment interfaces (ICAO, 2016). This framework enables a structured analysis of how technical and environmental factors interact to influence ATC performance.

RESEARCH METHODS

This study employed a quantitative approach using a positivist paradigm to analyze the influence of workplace facilities on the performance of Air Traffic Controllers (ATC) at the Area Control Centre Unit of AirNav, Jakarta Air Traffic Service Centre (JATSC). The quantitative design was selected because the study aimed to obtain objective, numerical data that could be systematically analyzed through statistical procedures. According to Sugiyono (2010), quantitative research produces measurable and replicable findings through standardized data collection and analysis techniques, allowing the relationship between variables to be tested empirically and objectively.

The study design was categorized as explanatory research, which aims to determine the causal relationship between independent and dependent variables in this case, workplace facilities (independent variable) and ATC performance (dependent variable). This approach allows for statistical testing of the extent to which workplace facilities affect ATC performance (Creswell, 2016).

Population and Sample

The population consisted of 238 Air Traffic Controllers assigned to the Area Control Centre (ACC) of AirNav JATSC. A simple random sampling technique was used to provide equal selection opportunities for each individual in the population and minimize selection bias. The minimum sample size was determined using Slovin's formula, resulting in 72 respondents, which was increased to 79 to anticipate incomplete responses.

Variables and Operational Definitions

The study included two main variables:

1. Independent Variable (X): *Workplace Facilities* defined as all physical and operational infrastructures provided by the organization to support ATC duties. It includes two dimensions based on the SHEL Model:
    a. Machines and Equipment (Liveware Hardware Interface) covering communication systems, radar displays, and operational control systems.
    b. Physical Infrastructure (Liveware-Environment Interface) covering lighting, room temperature, noise, ventilation, and ergonomic workspace (ICAO, 2016).
2. Dependent Variable (Y): *ATC Performance* measured through quality, quantity, reliability, and work attitude dimensions (Mangkunegara, 2013).

Research Location and Duration

The research was conducted at the Area Control Centre Unit of AirNav Indonesia's Jakarta Air Traffic Service Centre (JATSC), one of the busiest air traffic facilities in Indonesia. The study was carried out between August 2025 and January 2026, covering stages of observation, data collection, processing, and analysis.

Data Collection Techniques

Three data collection methods were used:

1. Questionnaire to gather ATC perceptions regarding workplace facilities and their influence on operational performance. The questionnaire adopted a 5 point Likert scale

(1 = strongly disagree to 5 = strongly agree) and was adapted from validated ATC research instruments.

2. Documentation to analyze organizational records, including facility inventories, maintenance logs, and incident reports, providing regulatory and administrative context (Creswell & Poth, 2016).
3. Secondary Data to validate quantitative findings through performance reports and internal safety statistics.

Data Analysis Techniques

Data were processed using SPSS version 25, beginning with data cleaning and variable coding. The analytical methods included:

1. Descriptive Statistics to describe respondent characteristics and variable distributions.
2. Validity and Reliability Tests using the Pearson Product Moment correlation and Cronbach's Alpha (> 0.6) for reliability (Ghozali, 2018).
3. Normality Test using the Kolmogorov–Smirnov test and P-P plots to ensure data normality.
4. Multiple Linear Regression Analysis to test the effect of the independent variables (X1: Machines and Equipment, X2: Physical Infrastructure) on ATC performance (Y), using the regression model:

$$Y = a + b_1X_1 + b_2X_2$$

5. t-test (Partial Test) to determine the individual effect of each variable.
6. F-test (Simultaneous Test) to determine the joint significance of all independent variables (Ghozali, 2018).

All analyses were conducted with a 5% significance level ($\alpha = 0.05$) to ensure the reliability of statistical conclusions.This methodological framework aligns with the standards of quantitative research in aviation human factors, allowing the study to produce empirical evidence on how workplace facilities affect the operational performance and safety of ATCs at JATSC.

RESULT AND DISCUSSION

The analysis of workplace facilities and Air Traffic Controller (ATC) performance at the Area Control Centre (ACC) of AirNav Indonesia, Jakarta Air Traffic Service Centre (JATSC), provides insights into how physical and operational infrastructures affect human performance in aviation control environments. Based on quantitative data from 79 respondents, this section presents the findings supported by tables and interpretive discussion.

Validity and Reliability Testing

Table 1 shows that all instrument items met the validity criteria, with correlation coefficients (r) exceeding the critical value of 0.221 for 79 respondents ($\alpha = 0.05$). This indicates that each question item accurately measures the intended variable. Reliability testing using Cronbach's Alpha produced values above 0.6 for all variables, confirming internal consistency and stability of the instrument (Ghozali, 2018).

Table 1. Instrument Validity and Reliability Results

Variable	Number of Items	r Count	r Table	Cronbach's Alpha	Interpretation
Workplace Facilities (X1, X2)	15	>0.221	0.221	0.894	Reliable
ATC Performance (Y)	10	>0.221	0.221	0.871	Reliable

These results indicate that the data collection instrument was both valid and reliable, allowing for accurate statistical analysis of variable relationships.

Descriptive Statistics

Descriptive analysis revealed that ATCs at JATSC rated workplace facilities as generally good, with an average Likert score between 3.41-4.20, aligning with the "Good" category (Sugiyono, 2010). This suggests that both machine-and-equipment infrastructure (Liveware–Hardware Interface) and physical facilities (Liveware - Environment Interface) are perceived positively overall, though certain aspects remain in need of improvement.

Table 2. Descriptive Summary of Research Variables

Variable	Mean	Category
Machines and Equipment (X1)	4.01	Good
Physical Infrastructure (X2)	3.88	Good
ATC Performance (Y)	4.05	Good

From the respondents' perceptions, the communication and radar systems were the most reliable elements, while ergonomic comfort and noise levels were identified as areas requiring optimization. These findings are consistent with ICAO's Human Factors Manual (Doc 9683), which emphasizes environmental and ergonomic support as determinants of controller alertness and decision accuracy (ICAO, 2016).

Normality and Regression Analysis

Normality testing using the Kolmogorov-Smirnov method yielded a significance value greater than 0.05, confirming that the residual data distribution is normal and thus appropriate for regression analysis (Ghozali, 2018).

The multiple linear regression model applied to the study is:

$$\mathbf{Y = a + b_1X_1 + b_2X_2}$$

where:

Y = ATC Performance

X_1 = Machines and Equipment

X_2 = Physical Infrastructure

Table 3. Regression Summary

Variable	Coefficient (B)	Sig.	Interpretation
Constant (a)	2.043	–	–
Machines and Equipment (X1)	0.423	0.001	Significant
Physical Infrastructure (X2)	0.295	0.004	Significant
Adjusted R^2	0.612	–	Model explains 61.2% variance

The results indicate that both machine-and-equipment facilities and physical infrastructure significantly influence ATC performance, jointly explaining 61.2% of performance variance, while 38.8% is influenced by other factors outside the study model. This supports the hypothesis (H_1) that workplace facilities significantly affect ATC performance.

Interpretation of Findings

The regression results demonstrate that machines and equipment (X_1) contribute more strongly to ATC performance than physical infrastructure (X_2). This implies that technical

reliability such as radar systems, communication clarity, and display accuracy is more critical in influencing operational efficiency and situational awareness. These findings align with Wickens et al. (2013), who stated that effective *Human-Machine Interfaces* (HMI) directly reduce cognitive load and communication errors in air traffic management environments.

Meanwhile, physical infrastructure variables such as lighting, noise control, and temperature regulation also showed a significant but lesser effect. These elements are essential for sustaining comfort and focus during prolonged monitoring tasks. ICAO (2016) emphasizes that inadequate physical environments can lead to fatigue, reduced alertness, and slower response times, all of which compromise safety.

Furthermore, the descriptive and inferential results confirm the importance of integrating ergonomic design principles into ATC workspace planning. This includes ergonomic consoles, adjustable lighting systems, noise-dampening materials, and controlled air circulation, consistent with the SHEL Model framework (Software, Hardware, Environment, Liveware) used by ICAO.

Discussion

The empirical findings reinforce that workplace facilities have a significant and positive impact on ATC performance. The more adequate and reliable the facilities, the higher the operational effectiveness and accuracy of controllers. The results support previous research by Ulandari & Dyahjatmayanti (2022), which found that unstable communication quality and signal interference negatively affect ATC performance, increasing the potential for human error.

These findings also validate Simanjuntak's (2011) theoretical assertion that performance is shaped not only by individual competence but also by the quality of organizational infrastructure and managerial support. The quantitative results from this study provide a measurable link between physical and technical facilities and performance outcomes within the aviation control context.

From a managerial perspective, AirNav Indonesia can utilize these findings to prioritize investment in modernized equipment, ensure regular maintenance, and improve ergonomic workspace designs. Such improvements can reduce fatigue, enhance communication clarity, and strengthen the overall reliability of air navigation services.

CONCLUSION

In summary, the integrated analysis shows that both machines and equipment and physical infrastructure significantly affect ATC performance at JATSC. Machines and equipment have a stronger influence, reflecting the importance of technological reliability in supporting operational precision and safety. Physical infrastructure also contributes meaningfully by sustaining ATC comfort and concentration. Therefore, it is recommended that AirNav Indonesia maintain a continuous improvement strategy for workplace facilities, integrating ergonomic assessments, human factors training, and technology updates to enhance safety and performance consistency in air traffic management.

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