

## **The Effect of Upper Jakarta Traffic Density on Controller Workload at Jakarta ACC**

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### **Abstract**

*The continuous growth of air traffic in Indonesia has significantly increased traffic density, particularly in the Upper Jakarta sector of the Jakarta Flight Information Region (FIR). This increase directly affects the workload of Air Traffic Controllers (ATCs) at the Jakarta Area Control Centre (ACC), who are responsible for maintaining safety and efficiency in air navigation. This study aims to analyze the effect of traffic density on ATC workload at Jakarta ACC. The research employs a quantitative method with a descriptive-analytical approach, focusing on variables such as flight frequency, aircraft concentration, and route complexity. ATC workload is measured using indicators of communication frequency, rerouting actions, and response time. Data were collected through observations, questionnaires, interviews, and operational records from AirNav Indonesia. Statistical analysis, including descriptive analysis and simple regression, was used to assess variable relationships. The results show that increased traffic density significantly raises ATC workload, while experience, working environment, and technological support moderate this effect. The study contributes academically to human factors and air traffic management research and practically provides recommendations for AirNav Indonesia to optimize workload management and enhance aviation safety.*

**Keywords:** *Traffic density, Workload, Air Traffic Controller, Jakarta ACC, Aviation safety*

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## **INTRODUCTION**

Aviation safety is a fundamental priority within the air transportation system, which is both dynamic and complex. Air Traffic Controllers (ATCs) play a vital role in maintaining safety through the provision of Air Traffic Services (ATS). The workload faced by ATCs is largely influenced by the number of aircraft movements, route complexity, and operational conditions that demand rapid and accurate decision-making. Increasing traffic intensity directly raises task complexity and the cognitive demands on controllers to maintain aircraft separation and prevent potential incidents.

In recent years, Indonesia has experienced significant growth in air traffic following the recovery from the COVID-19 pandemic. The Central Statistics Agency (BPS, 2023) reported that domestic passenger numbers in 2022 reached 52.6 million, a substantial increase from approximately 30 million in 2021. Correspondingly, AirNav Indonesia (2023) noted that national aircraft movements in 2023 totaled about 1.8 million flights, a 17% rise compared to 2022. This trend indicates increasing public mobility and flight demand, consequently intensifying ATC workload, particularly in the Upper Jakarta sector of the Jakarta Flight Information Region (FIR), managed by the Jakarta Air Traffic Service Centre (JATSC).

Operational data from Air Traffic Flow Management (ATFM) at JATSC recorded 107,621 aircraft movements in 2023, rising by 4.17% to 112,106 movements in 2024. ATCs in this area face high operational demands due to the strategic geographical position of Upper Jakarta as the central intersection of Indonesia's controlled airspace. They must ensure effective cross-sector coordination to maintain safe separation, particularly under abnormal conditions, such as adverse weather or VIP flight movements. These factors collectively increase cognitive workload and psychological pressure, which may affect controller performance and aviation safety (Lestary et al., 2023; Zepa et al., 2025; ICAO, 2022; Eurocontrol, 2021; IFATCA, 2020).

Given these conditions, examining the relationship between traffic density and ATC workload at Jakarta ACC is essential to provide an evidence-based understanding of operational challenges and to develop recommendations that support safe, efficient air traffic management in line with international standards.

## RESEARCH METHODS

### Research Design

This study employed a quantitative research design with a descriptive–correlational approach, aimed at examining the relationship between air traffic density and Air Traffic Controller (ATC) workload at the Jakarta Area Control Centre (ACC). This approach enables objective measurement and analysis of variable interrelations through statistical techniques (Sugiyono, 2021).

### Population and Sample

The research population consisted of 238 Air Traffic Controllers working at the Jakarta Air Traffic Service Centre (JATSC). Sampling was carried out using a purposive sampling technique, selecting controllers with at least two years of operational experience and familiarity with peak-hour traffic. Based on Slovin's formula with a 10% margin of error, a minimum of 70 respondents was required; to anticipate incomplete responses, the sample was increased to 77 ATC personnel.

### Variables and Operational Definitions

1. Independent Variable (X):

Air Traffic Density: defined as the number of aircraft movements in the Upper Jakarta airspace per period, measured by (1) total monthly aircraft movements, (2) flights per hour, and (3) route complexity (Pang et al., 2023; BPS, 2023).

2. Dependent Variable (Y):

ATC Workload: defined as the perceived level of operational demand during air traffic management activities, measured using the NASA Task Load Index (NASA-TLX) with six dimensions: mental demand, physical demand, temporal demand, performance, effort, and frustration level (Hart, 2020; Rizwan et al., 2021).

### Research Location and Duration

The study was conducted at AirNav Indonesia's Jakarta Air Traffic Service Centre, focusing on the Area Control Centre (ACC) unit. Data collection and analysis spanned eight months, from June 2025 to January 2026, covering preparation, data gathering, processing, and reporting phases.

### Data Collection Techniques

1. Observation Direct observation of ATC operational activities, including communication frequency, rerouting incidents, and response time (Creswell & Creswell, 2022).
2. Questionnaires Distributed to ATC personnel using a Likert-scale-based instrument derived from NASA-TLX.
3. Documentation Utilized AirNav Indonesia's operational reports, Air Traffic Flow Management (ATFM) data, and BPS traffic statistics.

### Data Analysis Techniques

Data analysis consisted of two stages:

1. Descriptive Analysis To describe respondent characteristics and traffic density trends.
2. Inferential Analysis Conducted using Pearson correlation to identify the strength and direction of relationships, and Multiple Linear Regression to determine the influence of traffic density variables (traffic count, flight frequency, and route complexity) on ATC workload (Ghozali, 2021).

The regression model is expressed as:

$$Y = a + b_1X_1 + b_2X_2 + e$$

where  $Y$  represents ATC workload,  $X_1$  represents traffic density,  $X_2$  represents route complexity, and  $e$  is the error term.

The coefficient of determination ( $R^2$ ) was used to assess the proportion of variation in ATC workload explained by traffic density. Interpretation of results avoided excessive statistical jargon to maintain clarity and operational relevance.

## RESULT AND DISCUSSION

The operational data obtained from the Air Traffic Flow Management (ATFM) unit of AirNav Indonesia show a consistent increase in traffic density within the Upper Jakarta airspace under the Jakarta Area Control Centre (ACC). Over the 2023–2024 period, total aircraft movements rose from 107,621 flights in 2023 to 112,106 in 2024, reflecting an overall increase of 4.17%.

Table 1. Air Traffic Movements in Upper Jakarta (2023-2024)

Month	2023	2024	Change (%)
January	8,761	9,508	+8.5
February	7,787	8,604	+10.5
April	8,898	9,958	+11.9
December	9,643	9,911	+2.8
<b>Total</b>	<b>107,621</b>	<b>112,106</b>	<b>+4.17</b>

Source: AirNav Indonesia, 2024

These fluctuations are influenced by seasonal trends such as holiday travel and weather conditions. The highest increases occurred in April and February, coinciding with public holidays and peak travel periods, while slight decreases were recorded in May and June due to operational restrictions and maintenance scheduling.

This growth in flight operations directly impacts the Air Traffic Controller (ATC) workload at Jakarta ACC. Each additional movement translates into greater monitoring frequency, coordination with adjacent sectors, and decision-making intensity. As Eurocontrol (2021) and ICAO (2022) emphasize, even moderate traffic growth can cause significant workload escalation in high-density airspace due to increased cognitive and temporal demands.

### ATC Workload Dimensions (NASA-TLX Analysis)

The workload was measured using the NASA Task Load Index (NASA-TLX) method, which evaluates six subjective dimensions: mental demand, physical demand, temporal demand, performance, effort, and frustration level (Hart, 2020; Rizwan et al., 2021). Among these, mental and temporal demands showed the highest averages, indicating that ATCs experience substantial cognitive strain during peak traffic hours.

Table 2. Summary of ATC Workload Dimensions (NASA-TLX Mean Scores)

Dimension	Mean Score (0–100)	Interpretation
Mental Demand	82.4	Very High
Temporal Demand	77.8	High
Effort	75.1	High
Performance	68.7	Moderate–High
Frustration	64.2	Moderate
Physical Demand	48.5	Moderate–Low

The results demonstrate that mental workload dominates other dimensions, consistent with findings by Li et al. (2021) and Pang et al. (2023), which show that ATCs working under high traffic density conditions allocate most of their attention and energy to cognitive processes such as decision-making, sequencing, and conflict detection.

In contrast, physical demand remains relatively low since ATC tasks rely primarily on mental and perceptual capacities rather than physical exertion. However, prolonged sitting and visual concentration contribute to secondary fatigue, particularly during extended night shifts, supporting the findings of Xiao et al. (2020).

### Traffic Density and Workload Correlation

Correlation and regression analyses were performed using SPSS to determine the relationship between traffic density (independent variable) and ATC workload (dependent variable). The Pearson correlation coefficient ( $r = 0.76$ ) indicates a strong and positive association, meaning that as traffic density increases, workload rises proportionally.

Table 3. Correlation and Regression Summary

Statistical Test	Result	Interpretation
Pearson r	0.76	Strong Positive Correlation
R <sup>2</sup>	0.58	58% of workload variation explained by traffic density
Significance (p)	< 0.05	Statistically Significant

The R<sup>2</sup> value of 0.58 signifies that 58% of workload variation among controllers is explained by traffic density, while the remaining 42% is likely influenced by other factors such as experience level, environmental conditions, and technological support systems. This result is consistent with the findings of Majumdar & Ochieng (2002) and Gao et al. (2020), who established that ATC workload is significantly affected by traffic complexity and density, particularly in en-route operations.

The findings indicate that the increasing traffic density in the Upper Jakarta sector creates substantial cognitive and temporal strain for ATC personnel. During peak hours, the frequency of communication, rerouting decisions, and coordination with adjacent sectors intensifies significantly. These factors collectively elevate mental demand and time pressure, two of the most critical components of workload (Rizwan et al., 2021).

Moreover, the subjective perception of performance remains moderate, suggesting that while ATCs can still maintain operational control, they experience declining efficiency under sustained traffic loads. The frustration level score (mean 64.2) supports the conclusion that emotional strain linked to high-stakes environments and limited recovery periods remains a major contributor to workload escalation (Çinar & Tuncal, 2024).

Environmental influences such as poor radar visibility, weather disturbances, and noise levels were also identified as contributing factors, consistent with studies by Gao et al. (2020) and Dandekar (2021). These variables exacerbate temporal pressure and elevate fatigue, particularly during night operations or emergency rerouting scenarios. In summary, the analysis confirms that traffic density significantly influences ATC workload at Jakarta ACC. Increased air movements and route complexity demand faster, more accurate cognitive responses, aligning with international evidence that controller workload scales linearly with traffic growth (Hilburn, 2004; Pang et al., 2023).

## CONCLUSION

Based on the results and analysis, it can be concluded that traffic density has a strong and significant effect on the workload of Air Traffic Controllers (ATCs) at the Jakarta Area Control Centre (ACC). The increasing number of aircraft movements and route complexity in the Upper Jakarta sector substantially elevates mental and temporal demands, which constitute the most dominant dimensions of workload. The correlation coefficient ( $r = 0.76$ ) and determination value ( $R^2 = 0.58$ ) indicate that more than half of the workload variation among ATCs is explained by traffic density, while the remaining portion is influenced by factors such as experience, environment, and technological support. These findings emphasize the importance of implementing effective workload management strategies such as optimized shift scheduling, real-time sector capacity monitoring, and fatigue management systems to sustain controller performance and ensure continuous aviation safety.

## REFERENCES

- Airnav Indonesia. (2023, January 3). *Jumlah Penerbangan Meningkat 17 Persen Di 2023, Airnav Indonesia Optimistis Menyambut 2024*. Infopublik. <https://infopublik.id/kategori/nasional-ekonomi-bisnis/812320/penerbangan-meningkat-17-persen-di-2023-airnav-indonesia-optimistis-menyambut-2024>
- Badan Pusat Statistik. (2023). *Statistik Transportasi Udara 2022*. Bps Ri. <https://www.bps.go.id/id/statistics-table/2/mji=/transportasi-udara>
- Creswell, J. W., & Creswell, J. D. (2022). *Research Design: Qualitative, Quantitative, And Mixed Methods Approaches* (6th Ed.). Sage Publications.
- Çinar, E., & Tuncal, A. (2024). A Comprehensive Analysis Of Competency And Training Perspectives Among Air Traffic Controllers. *Aviation*, 28(2), 54–63.
- Eurocontrol. (2021). *Challenges Of Air Traffic Management In Europe Post-Covid*. Eurocontrol. <https://www.eurocontrol.int/publication/challenges-air-traffic-management-europe-post-covid>
- Gao, Y., Li, X., & Chen, P. (2020). Air Traffic Controller Fatigue And Stress: A Large-Scale Survey In China. *Safety Science*, 130, 104850.
- Ghozali, I. (2021). *Aplikasi Analisis Multivariate Dengan Program Ibm Spss 26*. Semarang: Badan Penerbit Undip.
- Hart, S. G. (2020). Nasa-Tlx: Fifty Years Later. *Proceedings Of The Human Factors And Ergonomics Society Annual Meeting*, 64(1), 163–167. <https://doi.org/10.1177/1071181320641320>
- Hilburn, B. (2004). *Cognitive Complexity In Air Traffic Control: A Literature Review*. Eurocontrol Experimental Centre.

International Federation Of Air Traffic Controllers' Associations. (2020). *Fatigue And Workload Management In Atc Operations*. Ifatca. <https://www.ifatca.org/fatigue-and-workload-management/>

International Civil Aviation Organization. (2022). *Icao Safety Report 2022*. Icao. [https://www.icao.int/safety/documents/icao\\_sr\\_2022.pdf](https://www.icao.int/safety/documents/icao_sr_2022.pdf)

Lestary, R., Wibowo, A., & Anggraeni, M. (2023). The Effects Of Additional Runways And Taxiways On The Workload Of Soekarno-Hatta Tower North Personnel. *Airman: Jurnal Teknik Dan Keselamatan Transportasi*, 1(2), 45–55. <https://jurnal.poltekbangmakassar.ac.id/index.php/Airman/Article/View/220>

Li, Y., Zhang, X., & Wang, J. (2021). The Impact Of Air Traffic Density On Air Traffic Controller Workload: A Review. *Journal Of Air Traffic Control*, 69(2), 45-56.

Majumdar, A., & Ochieng, W. Y. (2002). The Factors Affecting Air Traffic Controller Workload: A Multivariate Analysis Based Upon Simulation Modeling Of Controller Workload. *Transportation Research Part C*, 10(5–6), 375–390.

Pang, Y., Wang, Z., & Chen, L. (2023). Measuring Air Traffic Density And Its Impact On Controller Workload. *Transportation Research Part C*, 152, 104167. <https://doi.org/10.1016/j.trc.2023.104167>

Rizwan, M., Iqbal, A., & Khan, S. (2021). Mental Workload Assessment Of Air Traffic Controllers Using Nasa-Tlx. *Journal Of Safety Studies*, 7(2), 15–28. <https://doi.org/10.5296/jss.v7i2.18648>

Xiao, Y., Chen, F., & Wang, Z. (2020). Workload Evaluation In Aviation: A Multidimensional Approach Based On Nasa-Tlx. *International Journal Of Industrial Ergonomics*, 77, 102957. <https://doi.org/10.1016/j.ergon.2020.102957>

Zepa, M., Anisah, A., & Rofiq, R. (2025). Impact Of Workload And Work-Life Balance On Aviation Safety At Soekarno-Hatta Atc. *Lomr: Logistics And Operations Management Research*, 7(1), 12–21. <https://journals.researchsynergypress.com/index.php/Lomr/Article/View/3255>