

## **Impact of Jakarta FIR Realignment on ATC Workload: Case Study of Upper Pangkalpinang Sector**

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### **Abstract**

*The rapid development of Indonesia's aviation industry necessitated the optimization of airspace management to enhance flight safety and efficiency. One strategic effort was the realignment of the Jakarta Flight Information Region (FIR) in March 2024. This study aims to examine the impact of this realignment on the workload of Air Traffic Controllers (ATC) in the Upper Pangkalpinang sector. Employing a quantitative correlational method, data were collected through NASA-TLX-based questionnaires distributed to 48 ATC personnel at the Jakarta Air Traffic Service Center (JATSC). Post-realignment data show a significant increase in flight traffic, with an average rise of 2,000 flights per month, contributing directly to higher ATC workload. Statistical analysis revealed a strong positive correlation ( $r = 0.918$ ) between FIR realignment and ATC workload. Regression analysis indicated that 84.3% of workload variance could be attributed to the FIR realignment. The highest workload dimensions experienced were mental demand, temporal demand, and effort. This study recommends implementing fatigue risk management strategies, upgrading air traffic management (ATM) systems, and providing continuous training to ATC personnel to support operational safety and performance.*

**Keywords:** *FIR Realignment, Atc Workload, Nasa-Tlx, Upper Pangkalpinang, Air Traffic Control*

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## **INTRODUCTION**

The rapid advancement of globalization and technology has significantly transformed the aviation industry. Air transportation has become the preferred mode of travel due to its efficiency, safety, and ability to connect Indonesia's vast archipelagic regions in a relatively short time. As an island nation, Indonesia relies heavily on air transport to support national mobility, economic growth, and connectivity. In this context, improving the quality of aviation services particularly in air navigation is essential to ensure safety, comfort, and operational efficiency.

In recent years, Indonesia's aviation industry has experienced significant growth driven by economic development, increased public mobility, and investment in aviation infrastructure. A key factor supporting this progress is airspace management, which plays a central role in maintaining safety and efficiency in flight operations. The regulation of the Flight Information Region (FIR) is crucial in this regard, as it defines the airspace where flight information and alerting services are provided to ensure operational safety and control. As stated by Nugraha (2018), FIRs not only ensure flight safety but also contribute to national revenue through overflight charges paid by aircraft transiting national airspace.

The Jakarta FIR realignment, implemented in March 2024, represents a strategic effort by Indonesia to strengthen airspace sovereignty and enhance air navigation efficiency, particularly in the Upper Pangkalpinang sector. According to Muhammad et al. (2022), the realignment has implications not only for airspace structure and flight patterns but also for the workload of Air Traffic Controllers (ATC) responsible for managing aircraft movements within the new configuration. The adjustment has altered air traffic routes and increased operational complexity, thereby potentially raising ATC workload and mental demand during real-time decision-making.

Data from the Jakarta Air Traffic Service Center (JATSC) indicate an average increase of 2,000 additional flights per month following the realignment. This surge in air traffic density increases the cognitive and temporal demands placed on ATCs, leading to a higher likelihood of fatigue, stress, and decreased performance accuracy. As noted by Ye (2019), excessive workload among controllers can impair concentration and decision-making, posing risks to aviation safety. Therefore, it is crucial to evaluate the extent of the FIR realignment's impact on ATC workload through a structured and data-based approach.

To mitigate these challenges, it is essential to strengthen the integration of automation and advanced air traffic management systems. The adoption of modern radar and data-based navigation tools can help controllers manage increasing traffic complexity more efficiently. However, as emphasized in the recommendations of this study and aligned with ICAO standards (ICAO, 2016), the effective utilization of such technologies requires continuous training and human adaptation to prevent operational strain during transition periods. Furthermore, communication between pilots and controllers remains a critical factor; under high workload conditions, clear and timely communication is vital to maintaining situational awareness and flight safety.

Based on the background described above, this research is titled “The Impact of Jakarta FIR Realignment on Air Traffic Controller Workload: A Case Study of the Upper Pangkalpinang Sector.” The study aims to analyze the relationship between FIR realignment and ATC workload levels in the Upper Pangkalpinang sector and to identify factors contributing to workload variation after the implementation of the new FIR structure

## RESEARCH METHODS

This study applies a quantitative correlational research design aimed at determining the effect of the Jakarta Flight Information Region (FIR) realignment on the workload of Air Traffic Controllers (ATC) in the Upper Pangkalpinang sector. The research was conducted at Jakarta Air Traffic Service Center (JATSC), part of AirNav Indonesia, which manages upper airspace control operations after the FIR restructuring in March 2024.

### Subjects and Sampling

The population of this study consists of 240 ATC personnel at JATSC with Area Control Surveillance (ACS) ratings. Using Arikunto's sampling formula (2019), 20% of the population or 48 respondents were selected as the representative sample. The sampling technique used is saturated sampling, considering the limited and specialized scope of the population.

### Variables

The independent variable (X) is the Jakarta FIR realignment, defined as the adjustment of airspace boundaries that influences traffic volume and complexity. The dependent variable (Y) is the workload of Air Traffic Controllers, measured by perceived task demand during air traffic management operations.

### Research Instruments

Data were collected through a structured questionnaire developed using the NASA Task Load Index (NASA-TLX) method (Dewi & Bakhtiar, 2024). This tool evaluates six workload dimensions: Mental Demand, Physical Demand, Temporal Demand, Effort, Performance, and Frustration. Each dimension is scored based on respondents' subjective perception during operational duty.

### Data Collection Techniques

Two main techniques were used:

1. Observation, to understand actual operational conditions and identify observable and non-observable tasks performed by ATC.

2. Questionnaires, distributed to respondents post-duty using a Likert scale (Sugiyono, 2019) to quantify attitudes and perceptions about workload and traffic complexity after FIR realignment.

### Data Analysis

The collected data were analyzed using SPSS version 25. Statistical tests included:

1. Normality Test to verify data distribution,
2. Pearson Product-Moment Correlation to identify the relationship between FIR realignment and ATC workload, and
3. Simple Linear Regression to determine the strength and direction of influence.

The analysis follows the approach described by Sugiyono (2019) for quantitative hypothesis testing. Statistical interpretations were made at a 5% significance level.

## RESULT AND DISCUSSION

This research was conducted at the Jakarta Air Traffic Service Center (JATSC) under AirNav Indonesia, which is responsible for managing airspace control within the Jakarta Flight Information Region (FIR). Following the Jakarta FIR realignment in March 2024, the Upper Pangkalpinang sector experienced a significant increase in flight traffic, averaging 2,000 additional movements per month. This surge in air traffic complexity potentially affected the workload of Air Traffic Controllers (ATC) assigned to the area. The analysis below summarizes the quantitative findings and their interpretation in relation to the research objectives.

### Descriptive Analysis of Key Variables

Table 1. Summary of Descriptive Statistics Realignment Jakarta FIR (Variable X)

No	Statistic	Value	Description
1	Mean	53.73	High category (Likert mean $\approx$ 4.13)
2	Median	53	Central value in "High" category
3	Mode	51	Most frequent response
4	Std. Deviation	5.06	Low data variability
5	Minimum	44	Moderate category
6	Maximum	65	Excellent category

The mean score of 53.73 indicates that most respondents perceived the FIR realignment positively, showing readiness in handling operational transitions. The low standard deviation (5.06) reflects homogeneous responses, implying consistent perceptions among ATCs regarding the operational effectiveness of the FIR changes.

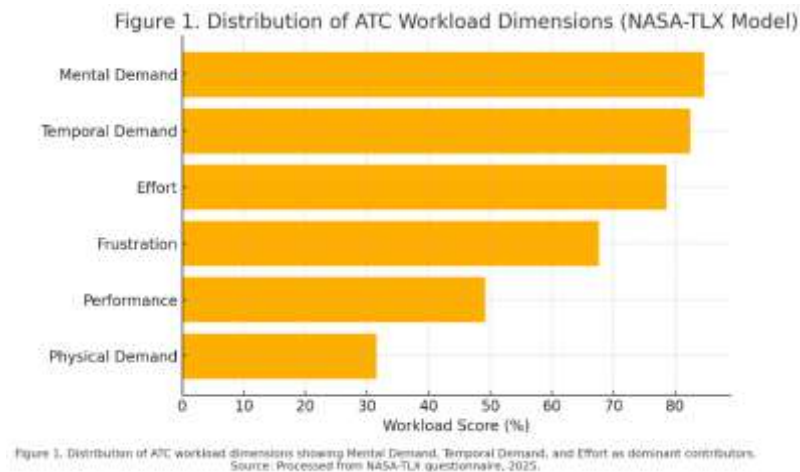


Figure 1. Distribution of ATC Workload Dimensions (NASA-TLX Model)

Based on the NASA Task Load Index (NASA-TLX) assessment, the three most dominant workload dimensions were Mental Demand (84.71), Temporal Demand (82.46), and Effort (78.56). This implies that ATCs experienced high cognitive and time pressure while maintaining performance efficiency in managing increasing traffic density. Physical Demand scored the lowest (31.52), indicating that the tasks were primarily mental rather than physical.

The weighted workload analysis revealed that nearly one-third of the total workload originated from mental processing such as problem-solving, route planning, and conflict detection. Temporal pressure, including short decision windows and communication timing, accounted for a similar proportion. These results highlight that cognitive and time-related demands dominate the overall workload in air traffic control operations.

### Correlation and Regression Analysis

Pearson correlation analysis showed a strong positive relationship ( $r = 0.918$ ) between FIR realignment (X) and ATC workload (Y). This means that the better the implementation and operational intensity of the FIR realignment, the higher the reported ATC workload. The correlation is statistically significant ( $p < 0.05$ ), confirming that the FIR adjustment directly affects ATC's perceived task load.

Simple linear regression produced the equation:  $\hat{Y} = 21.723 + 1.000X$ , indicating a direct and proportional relationship between the two variables. The coefficient of determination ( $R^2 = 0.843$ ) shows that 84.3% of workload variation can be explained by the FIR realignment, while 15.7% is attributed to other operational or environmental factors.

### Interpretation and Discussion

The high correlation between FIR realignment and ATC workload suggests that operational restructuring significantly influences controller performance demands. Increased traffic complexity and communication frequency following the 2024 FIR boundary adjustment required ATCs to manage more simultaneous aircraft, thus increasing cognitive strain and temporal stress. This finding aligns with previous studies by Muhammad et al. (2022) and Ye (2019), which identified workload escalation following structural or procedural airspace changes.

Moreover, the results emphasize the importance of implementing effective fatigue risk management (FRM) and enhancing automation integration. Continuous improvement of Air Traffic Management (ATM) tools, supported by adaptive shift scheduling and regular simulation-based training, is crucial to sustain controller alertness and maintain safety performance under high workload conditions.

Table 2. Summary of Key Statistical Findings

No	Analysis Type	Result	Interpretation
1	Correlation (r)	0.918	Very strong positive relationship
2	Significance (p)	0.000	Statistically significant
3	Determination (R <sup>2</sup> )	0.843	84.3% variance explained
4	t-value	15.692	Realignment significantly affects workload

### Implications

The findings confirm that the Jakarta FIR realignment has a statistically significant and operationally relevant impact on ATC workload in the Upper Pangkalpinang sector. The mental and temporal demands identified through NASA-TLX are crucial indicators of performance sustainability. These results support the implementation of a data-driven workload management strategy, combining technological solutions, human factor training, and fatigue mitigation.

Future research is recommended to include multivariate models integrating traffic density, automation level, and sector complexity to better predict workload fluctuations in post-realignment operations.

### CONCLUSION

The results of this study demonstrate that the Jakarta FIR realignment has a substantial and measurable influence on the workload of Air Traffic Controllers in the Upper Pangkalpinang sector. The strong correlation between operational changes and workload levels highlights that the realignment not only increased traffic volume but also intensified mental and temporal demands on controllers. These findings emphasize the importance of integrating effective workload management, technological adaptation, and fatigue mitigation strategies within air navigation operations to maintain safety, efficiency, and performance consistency in increasingly complex airspace environments.

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