

Analysis of the Procedural Controller Function on Workload at the Area Control Centre (ACC) JATSC

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Abstract

This study analyzes the function of procedural controllers and its influence on workload at the Area Control Centre (ACC) within the Jakarta Air Traffic Service Centre (JATSC). Unlike radar controllers who operate with real-time visual aids, procedural controllers rely on communication, coordination, and pilot reports, resulting in a higher mental and cognitive workload. The research aims to identify how procedural control functions contribute to workload levels and how these functions can be optimized to maintain operational safety and efficiency. The study adopts a quantitative method with a descriptive-correlation approach. Data were collected through observations, semi-structured interviews, and closed-ended questionnaires using a five-point Likert scale. Respondents consisted of active Air Traffic Controllers (ATCs) at ACC JATSC, selected using purposive sampling with at least one year of work experience. Data analysis was performed using multiple linear regression to evaluate both simultaneous and partial effects of procedural control functions on workload. The findings show that high adherence to standard operating procedures (SOP), consistent application of procedures, and effective communication significantly reduce perceived workload. However, procedural controllers continue to face moderate-to-high levels of mental and physical workload due to sustained cognitive demands, communication intensity, and time pressure. The study concludes that optimizing procedural control functions serves as a protective mechanism against excessive workload, supporting safety, efficiency, and the well-being of ATC personnel at JATSC.

Keywords: *Procedural controller, workload, Air Traffic Control, ACC JATSC, communication effectiveness*

INTRODUCTION

The growth of global air traffic over the past two decades has shown a rapid and consistent increase. According to the International Air Transport Association (IATA, 2023), the number of air passengers is projected to reach 8.4 billion by 2036. This growth has led to a corresponding rise in aircraft movements and operational complexity, particularly in Southeast Asia, one of the world's busiest aviation regions. Indonesia, positioned strategically between Asia and Australia, manages a highly congested airspace through the Jakarta Flight Information Region (FIR), administered by the Jakarta Air Traffic Service Centre (JATSC). This center handles thousands of daily aircraft movements across domestic and international routes, including major corridors such as East Asia-Australia and South Asia-Pacific.

The Area Control Centre (ACC) within JATSC operates using both radar surveillance and procedural control systems. Procedural control relies on rule-based air traffic management through pilot reports, estimated aircraft positions, and inter-unit coordination without direct radar visualization. This method is essential in non-radar areas or during radar outages and peak traffic periods. Unlike radar controllers who use real-time displays, procedural controllers depend on manual calculations and verbal coordination, which increase mental and cognitive workload. According to Wickens (2008) in the Multiple Resource Model, excessive cognitive load can reduce performance accuracy and heighten error probability once mental capacity limits are surpassed. Supporting studies by Eurocontrol (2021) highlight that excessive workload may diminish communication efficiency and decision-making speed, thereby increasing the risk of human error.

Despite extensive global research on air traffic controllers' workload, most studies primarily focus on radar controllers, while the workload and role of procedural controllers remain underexplored. This research gap is significant, especially within dense and complex airspace such as Jakarta FIR. Procedural controllers operate under continuous time pressure and high cognitive demand, making it essential to examine how their role influences workload and safety performance (Ibanez et al., 2023; Suarez et al., 2024). Investigating this relationship in the ACC JATSC context provides both academic and practical value. Academically, the study enriches existing literature on air traffic controller workload by emphasizing procedural control operations. Practically, it provides valuable insights for AirNav Indonesia in optimizing workload management, scheduling, and procedural training systems.

The research problem addressed in this study can be formulated as follows: *To what extent does the function of procedural controllers influence workload among personnel at ACC JATSC?*. The objectives of this research are: (1) to analyze the influence of procedural controller functions on the workload of personnel at ACC JATSC, and (2) to provide recommendations for workload management and operational improvement in procedural air traffic control sectors. The outcomes of this study are expected to support policy formulation on workload management, personnel allocation, and the development of cognitive and procedural training systems to enhance operational efficiency and safety performance within Indonesia's air navigation services.

RESEARCH METHODS

This study employed a quantitative research method with a descriptive-correlational approach to analyze the influence of procedural controller functions on workload among Air Traffic Controllers (ATCs) at the Area Control Centre (ACC) of Jakarta Air Traffic Service Centre (JATSC). This method was chosen to describe the current conditions empirically and statistically, as well as to identify the strength and nature of the relationship between independent and dependent variables (Sugiyono, 2018).

The population of the study consisted of all active ATCs serving at ACC JATSC. The sample was determined using the purposive sampling technique, with inclusion criteria of personnel who directly perform procedural control operations and possess at least one year of working experience. The total number of respondents was adjusted based on available data, representing approximately 30-50 controllers.

The independent variable (X) was the *function of the procedural controller*, which includes adherence to standard operating procedures (SOP), consistency in implementation, and communication effectiveness (Suarez, 2024). The dependent variable (Y) was *workload*, defined as the total perceived mental and physical demands experienced during air traffic control operations (Prayoga, 2024). Indicators for workload included mental demand, number of tasks, and levels of stress and fatigue.

Data collection techniques

Comprised of two primary methods:

1. Closed-ended questionnaires, using a five-point Likert scale to quantify respondents' perceptions of procedural function implementation and workload dimensions.
2. Direct observation, conducted to validate questionnaire data by monitoring real-time controller activities, communication patterns, and coordination processes in procedural sectors (Arikunto, 2010).

The research instrument (questionnaire) was structured systematically to ensure reliability and validity, covering three dimensions of the procedural function and three dimensions of

workload. This structure facilitated the conversion of subjective perceptions into measurable quantitative data.

Data analysis utilized multiple linear regression to evaluate both simultaneous and partial effects of independent variables on the dependent variable (Ghozali, 2018). The model was used to identify which aspects of procedural functions SOP adherence, consistency, or communication effectiveness had the most substantial influence on workload. The regression results were further supported by descriptive statistics to illustrate the overall trends in workload intensity among procedural controllers.

Ethical considerations were maintained by ensuring respondent anonymity and voluntary participation. The findings were interpreted within the framework of human factors and cognitive ergonomics theories, emphasizing the relationship between procedural standardization, mental workload, and performance efficiency (Wickens, 2008; Eurocontrol, 2021).

RESULT AND DISCUSSION

The results of this research reveal that the workload level of procedural controllers at the Area Control Centre (ACC) of Jakarta Air Traffic Service Centre (JATSC) is categorized as moderate to high. Based on the quantitative data analysis, it was found that the three main dimensions of procedural control adherence to standard operating procedures (SOPs), consistency in application, and communication effectiveness significantly influence the perceived workload of controllers. The regression analysis demonstrates that adherence to SOPs and communication effectiveness exhibit the strongest influence in reducing perceived workload intensity, whereas consistency in procedural application plays a stabilizing role in maintaining performance under high operational pressure. These findings suggest that procedural precision and communication clarity are essential in ensuring that operational efficiency is maintained despite the cognitive and temporal demands of air traffic management tasks.

Procedural controllers at ACC JATSC operate in a high-reliability system environment characterized by time-sensitive decision-making, heavy cognitive processing, and high communication intensity. Within such an environment, even minor lapses in procedure can result in a disproportionate increase in workload and potential safety risks. The research indicates that procedural mastery functions as a cognitive buffer that mitigates the adverse effects of workload accumulation. Controllers who consistently follow established procedures demonstrate greater situational awareness, lower levels of mental strain, and improved coordination efficiency during complex operational scenarios. This pattern highlights that procedural discipline is not merely a compliance factor but a key determinant of operational stability and human performance quality.

Furthermore, the findings align with cognitive ergonomics principles emphasizing the role of structured mental frameworks in managing workload. As explained by Wickens (2008) and Eurocontrol (2021), procedural frameworks act as “mental scaffolds” that stabilize working memory, enhance focus, and enable controllers to handle multiple information channels without cognitive overload. The procedural system thus operates as both a regulatory and adaptive mechanism providing consistency while allowing flexibility in decision-making during dynamic traffic conditions. Overall, this study underscores that enhancing procedural training and reinforcing communication protocols are essential strategies for sustaining optimal performance and safety within complex air traffic control operations.

Table 1. Average Dimensions of ATC Workload at ACC JATSC

Workload Dimension	Category	Description
Mental Demand	High	Continuous attention and multi-tasking on multiple

		aircraft without radar visualization
Physical Demand	Moderate	Extended sitting posture and repetitive communication tasks
Temporal Demand	Moderate	Tight scheduling during peak hours
Effort	High	Cognitive strain in time estimation and coordination
Frustration	Moderate	Psychological pressure due to safety responsibility

The results indicate that mental workload dominates overall workload perception, primarily due to sustained cognitive processing and manual estimation of aircraft positions. The requirement to construct and maintain a mental traffic picture using only pilot reports and inter-sector coordination significantly increases cognitive load (Ibanez et al., 2023). However, the high adherence to SOPs among JATSC procedural controllers mitigates the negative impact of workload by providing structured decision-making pathways. The use of standardized ICAO phraseology ensures clarity and prevents miscommunication, which further reduces cognitive uncertainty during high-traffic conditions (ICAO, 2018).

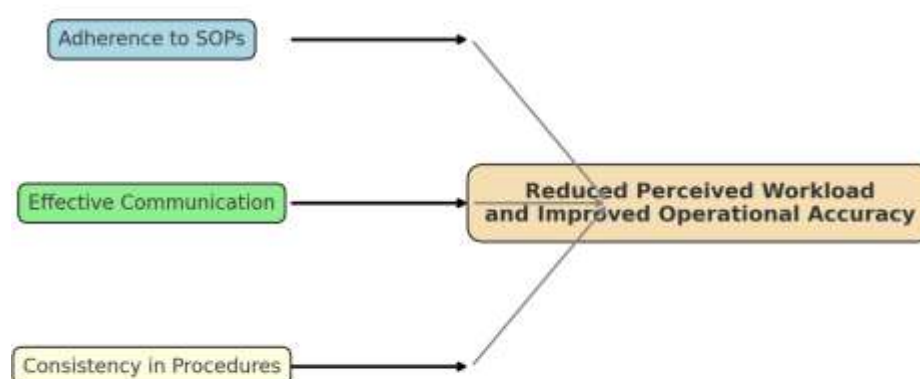


Figure 1. Relationship Between Procedural Function and Controller Workload

Source: Processed Research Data (2025)

Figure 1. Relationship Between Procedural Function and Controller Workload

Communication effectiveness is found to have a direct compensatory effect on workload. Controllers who engage in precise, clear, and timely radio communication demonstrate lower stress indicators, as unnecessary repetition or clarification is minimized. This observation supports findings by Furstenau and Raduntz (2021), who argue that communication efficiency directly affects controller workload and cognitive strain. Furthermore, psychological stress arising from safety responsibility and decision consequences remains a notable aspect of workload but does not significantly degrade performance indicating robust psychological resilience among ACC JATSC personnel, likely reinforced by ongoing training and organizational safety culture (Sonhaji et al., 2024).

From an organizational perspective, workload management at ACC JATSC requires a balanced approach between procedural compliance and mental recovery. Shift rotations, task allocation, and rest schedules should be structured to prevent chronic fatigue accumulation. The

results confirm that workload intensity, while moderate to high, remains within adaptive limits demonstrating that controllers possess effective coping mechanisms supported by institutional procedures (Bongo & Seva, 2021).

In synthesis, the research findings reinforce that optimal procedural control functions strong SOP adherence, consistent implementation, and effective communication serve as protective mechanisms against excessive workload. Procedural mastery enhances efficiency, reduces cognitive demand, and maintains safety performance even under complex traffic conditions. The implications for AirNav Indonesia emphasize the need to strengthen procedural training, promote fatigue management programs, and implement workload monitoring systems to sustain operational safety and controller well-being.

CONCLUSION

The findings of this study demonstrate that the function of procedural controllers significantly influences workload among Air Traffic Controllers (ATCs) at the Area Control Centre (ACC) of Jakarta Air Traffic Service Centre (JATSC). High adherence to standard operating procedures (SOPs), consistent procedural implementation, and effective communication collectively contribute to reducing mental strain and enhancing operational precision. Despite operating under high cognitive demand and time pressure, procedural controllers maintain satisfactory performance levels through structured procedural frameworks and professional discipline. The study confirms that procedural mastery not only mitigates the effects of workload but also serves as a critical safeguard for flight safety and service efficiency. These results underscore the importance of continuous procedural training, workload monitoring, and ergonomic support to ensure sustainable controller performance and operational resilience within complex air traffic environments.

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