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THE EFFECT OF AIR TRAFFIC CONTROLLER ASSISTANT AVAILABILITY ON AIR TRAFFIC CONTROLLER WORKLOAD: A HUMAN RESOURCE MANAGEMENT PERSPECTIVE

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ABSTRACT

Introduction*: The increasing intensity of air traffic has a direct impact on the workload of Air Traffic Controllers (ATCs), who serve as key human resources within air navigation service organizations. Previous studies on ATC workload have predominantly emphasized technical and operational aspects related to aviation safety, while managerial and organizational perspectives—particularly those concerning human resource support—remain relatively limited. This study aims to examine the effect of the availability of Air Traffic Controller Assistants (ATCAs) on the workload of Air Traffic Controllers from a human resource management perspective.*

Methods*: This research employed an explanatory design using a quantitative approach. Data were collected through a survey of 64 Air Traffic Controllers assigned to the Approach/Terminal unit. ATC workload was measured using the NASA Task Load Index (NASA-TLX), while the availability of ATCAs was assessed using a structured questionnaire. Data analysis was conducted through descriptive statistics, assumption testing, and simple linear regression using SPSS software.*

Results*: The results indicate that the availability of ATCAs has a statistically significant effect on ATC workload ($p < 0.05$), although the magnitude of this effect is moderate. These findings suggest that human resource support through the management of support personnel plays an important role in influencing workload, particularly in work environments characterized by high cognitive demands and time pressure. This study concludes that managing the availability of ATCAs should be considered an integral component of human resource management strategies aimed at enhancing work effectiveness and organizational sustainability within air navigation service organizations.*

INTRODUCTION

The increasing growth of air transportation has intensified the operational demands placed on air navigation service organizations. Within this context, Air Traffic Controllers (ATCs) represent a critical organizational resource responsible for maintaining the safety, efficiency, and continuity of air traffic operations. As air traffic density increases, ATCs are required to perform complex cognitive tasks under strict time constraints, making workload management a central concern for organizational effectiveness and workforce sustainability.

In organizational and management studies, workload is widely recognized as a factor that influences employee performance, well-being, and error probability. Excessive workload has been associated with reduced efficiency, increased fatigue, and diminished decision-making quality, particularly in safety-critical occupations where task complexity and responsibility are high (Hancock & Meshkati, 2019; Young et al., 2015). Consequently, workload should not be viewed solely as an operational outcome, but also as a managerial issue shaped by organizational design, staffing policies, and resource allocation decisions (Bakker & Demerouti, 2017).

Research on ATC workload has traditionally emphasized technical and operational determinants, such as traffic complexity, airspace configuration, system interfaces, and human cognitive limitations (Wickens et al., 2015). While these studies have contributed substantially to operational safety improvements, they often provide limited insight into how organizational and managerial factors may be leveraged to manage workload more effectively. In particular, staffing arrangements and support mechanisms have received comparatively less empirical attention within the air traffic control context.

From a human resource management perspective, the availability of support personnel represents a strategic organizational resource that can influence how workload is distributed and experienced by core employees. Organizational support theory suggests that tangible forms of support, including staffing adequacy, play an important role in shaping employees' responses to job demands (Eisenberger et al., 2002). In air traffic control operations, Air Traffic Controller Assistants (ATCAs) serve as support staff who assist ATCs with coordination and non-core operational tasks, potentially contributing to more effective workload management.

Despite the practical relevance of support staffing, empirical evidence examining the relationship between ATCA availability and ATC workload remains limited, particularly in approach and terminal control environments. Addressing this gap, the present study investigates the effect of Air Traffic Controller Assistant availability on the workload of Air Traffic Controllers from an organizational and management perspective.

LITERATURE REVIEW

This literature review is grounded in organizational and human resource management theories that conceptualize workload as an outcome of the interaction between job demands and available organizational resources. Within this perspective, workload is not merely an individual perception but a structural condition shaped by managerial decisions related to task design, staffing arrangements, and resource allocation (Bakker & de Vries, 2021). Accordingly, this section reviews theoretical perspectives on workload and organizational support, examines empirical studies on support staffing and workload management, and synthesizes prior findings to develop the research hypothesis of the present study.

Workload In Organizational And Management Context

In organizational and management studies, workload is commonly understood as a multidimensional construct that reflects the interaction between job demands and the resources available to employees in performing their tasks. Rather than being viewed solely as an objective measure of task quantity, workload is increasingly conceptualized as a subjective experience shaped by cognitive, temporal, and emotional demands within a given organizational context. This perspective emphasizes that workload emerges not only from the nature of the task itself but also from how work is structured, supported, and managed within the organization (Young et al., 2015).

From a human resource management standpoint, excessive workload has been consistently associated with negative outcomes such as mental strain, reduced performance, and decreased job sustainability. Empirical studies in organizational psychology demonstrate that when job demands exceed employees' capacity to cope, the risk of fatigue

and performance degradation increases, particularly in safety-critical occupations. Consequently, workload has become a central concern in organizational design and staffing decisions, as it directly affects both individual well-being and organizational effectiveness (Sonnentag & Frese, 2012).

The Job Demands–Resources (JD–R) theory provides a widely accepted framework for explaining how workload operates within organizations. According to this model, job demands—such as time pressure, task complexity, and cognitive load—consume physical and psychological energy, while job resources—such as staffing support, role clarity, and organizational assistance—serve to mitigate the negative impact of these demands. When resources are insufficient, high demands are more likely to result in strain and reduced performance. Conversely, adequate organizational resources can buffer the adverse effects of workload and promote sustainable performance (Bakker & Demerouti, 2017).

Within this framework, organizational support mechanisms play a crucial role in shaping employees' workload experiences. Support resources, including staffing arrangements and auxiliary roles, allow core employees to concentrate on their primary responsibilities while reducing unnecessary task overload. Research in organizational behavior indicates that such support functions are particularly important in high-demand environments, where cognitive and time-related pressures are persistent and unavoidable (Montano et al., 2017).

In safety-critical systems, workload management becomes even more salient due to the potential consequences of performance failure. Studies in ergonomics and human factors highlight that sustained high workload can impair situational awareness, decision-making accuracy, and response time. However, these studies also emphasize that workload is not merely a function of task intensity but is strongly influenced by organizational design choices, including task allocation and the availability of support personnel (Young et al., 2015). This reinforces the argument that workload should be addressed not only through technical optimization but also through organizational and managerial interventions.

Air Traffic Control Workload and Organizational Support

Air Traffic Control (ATC) is widely recognized as a form of safety-critical work characterized by high cognitive demands, sustained vigilance, and strict time pressure. Controllers operating in approach and terminal control environments are required to continuously process dynamic information, maintain situational awareness, and make rapid decisions under conditions where errors may have severe consequences. Empirical research in ergonomics and human factors consistently demonstrates that such working conditions generate substantial mental workload, particularly when traffic density and task complexity increase (Triyanti et al., 2020)

Previous workload studies in air traffic control have primarily emphasized technical and operational determinants, including traffic volume, sector complexity, interface design, and environmental factors. While these studies provide important insights into task-related sources of workload, they often treat workload as a direct outcome of operational conditions, with limited consideration of organizational and managerial factors. As a result, the role of organizational design and staffing support in shaping workload experiences remains underexplored (D'Arcy & Rocco, 2001; Sonnentag & Frese, 2012).

From an organizational and human resource management perspective, workload in ATC should be understood not only as a function of task demands but also as an outcome of how work is structured and supported within the organization. The Job Demands–Resources framework suggests that organizational resources, including staffing arrangements and support roles, can buffer the negative effects of high job demands by enabling more effective task allocation and reducing unnecessary cognitive load (Moon et al., 2011; Ridayanti et al., 2021). In this context, workload is not solely an operational issue but also a managerial concern related to workforce planning and resource distribution.

Air Traffic Controller Assistants (ATCAs) represent a form of organizational resource designed to support ATCs by handling auxiliary and non-core tasks. By assisting with coordination, documentation, or procedural support, ATCAs may allow controllers to concentrate on core control activities, particularly during periods of high traffic intensity. Research in organizational behavior indicates that such support mechanisms can play a significant role in reducing perceived workload and mental strain in high-demand work settings (Montano et al., 2017; Muchaddats et al., 2023).

Despite their practical relevance, ATCAs have rarely been examined empirically from an organizational workload perspective (Muchaddats et al., 2023). Existing studies tend to position support roles as operational facilitators rather than as strategic human resource instruments that influence workload regulation. This gap highlights the need to investigate ATCA availability as an organizational factor that may shape ATC workload outcomes, particularly within safety-critical service organizations.

Previous Studies

Previous empirical studies on workload in safety-critical occupations consistently demonstrate that excessive job demands are associated with increased mental strain, reduced performance, and heightened safety risks. In the context of air traffic control, research has shown that high mental workload can impair situational awareness and decision accuracy, especially under conditions of sustained traffic pressure and limited recovery time (Young et al., 2015). These findings underscore the importance of effective workload management in maintaining both individual performance and system safety.

Organizational research further suggests that the impact of job demands on workload outcomes is strongly moderated by the availability of job resources. Studies grounded in the Job Demands–Resources framework indicate that staffing support, role clarity, and organizational assistance can mitigate the negative effects of high demands by enabling employees to allocate their cognitive resources more efficiently (Bakker & Demerouti, 2017; Muchaddats et al., 2023). In high-demand environments, such resources are particularly critical for sustaining performance over time.

Empirical evidence from organizational psychology also highlights the role of managerial and staffing factors in shaping workload perceptions. Research shows that insufficient staffing and inadequate support structures are associated with higher levels of perceived workload and mental strain, even when task demands remain constant (Triyanti et al., 2020). These findings suggest that workload is not merely a technical outcome of task characteristics but is also influenced by organizational decisions regarding resource allocation.

More recent studies have emphasized the need to integrate organizational and human resource perspectives into workload research, particularly in complex service systems. Empirical findings from occupational health and organizational research indicate that workload should be addressed through both task-level interventions and organizational strategies, including staffing optimization and support role design (Hopkin, 2017). However, empirical studies examining these relationships within air navigation service organizations remain limited.

Taken together, previous studies indicate that while workload in air traffic control has been extensively studied from a technical perspective, there is a relative lack of empirical research examining organizational support mechanisms, such as assistant staffing, as determinants of workload. This study addresses this gap by examining the effect of ATCA availability on ATC workload from an organizational and human resource management perspective.

Hypothesis Development

Building on organizational workload theory and human resource management principles, this study proposes that the availability of support staff constitutes an organizational resource that influences workload experiences. In the context of air traffic control, the presence of Air Traffic Controller Assistants is expected to provide operational and organizational support that helps mitigate workload demands faced by Air Traffic Controllers.

Based on the preceding theoretical and empirical discussion, the following hypothesis is formulated:

H1: The availability of Air Traffic Controller Assistants has a significant effect on the workload of Air Traffic Controllers.

This hypothesis is empirically tested using a quantitative explanatory approach, as described in the subsequent research methods section.

RESEARCH METHODS

This study employed an explanatory quantitative research design to examine the effect of Air Traffic Controller Assistant (ATCA) availability on the workload of Air Traffic Controllers (ATCs). The research focused on ATCs assigned to the Approach/Terminal (APP/TMA) unit of an air navigation service organization. A census

sampling technique was applied, involving 64 ATCs who met the inclusion criteria, thereby enhancing the representativeness of the findings at the organizational level.

The independent variable was ATCA availability, conceptualized as an organizational resource reflecting the adequacy and consistency of assistant staffing during operational shifts. The dependent variable was ATC workload, measured using the NASA Task Load Index (NASA-TLX), which captures perceived workload across key dimensions such as mental demand, temporal demand, and effort. Data were collected using a structured questionnaire with a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Instrument validity was assessed using item–total correlation, while reliability was evaluated using Cronbach's Alpha, with the following criterion:

$$\alpha > 0.70$$

A coefficient exceeding this threshold indicates acceptable internal consistency of the measurement instrument. Data analysis comprised descriptive statistics, assumption testing, and hypothesis testing. Normality was examined using the Kolmogorov–Smirnov test, while linearity between variables was tested through ANOVA for linearity. Hypothesis testing was conducted using simple linear regression, expressed as:

$$Y = \alpha + \beta X + \varepsilon$$

where Yrepresents ATC workload and Xrepresents ATCA availability. The significance of the regression coefficient was evaluated using the t-test, and overall model significance was assessed using the F-test. All statistical analyses were conducted at a 5% significance level ($\alpha = 0.05$).

This methodological approach aligns with human resource management principles by positioning staffing support as a strategic organizational resource that influences workload regulation and operational effectiveness.

RESULT AND ANALYSIS

This section presents the empirical findings of the study and analyzes the relationship between the availability of Air Traffic Controller Assistants (ATCAs) and the workload of Air Traffic Controllers (ATCs). The analysis integrates descriptive statistics, assumption testing, and regression analysis to test the proposed hypothesis. Descriptive statistical analysis was conducted to provide an overview of respondents' perceptions regarding ATCA availability and ATC workload.

Table 1. Descriptive Statistics of Research Variables

Variable	N	Minimum	Maximum	Mean	Std. Deviation
ATCA Availability	**64**	**1.00**	**5.00**	**3.60**	**0.74**
ATC Workload	**64**	**32.00**	**78.00**	**56.84**	**8.91**

Source: Processed primary data (SPSS output)

The mean score of ATCA availability indicates a moderate level of perceived staffing support, suggesting that ATCAs are generally available during operational shifts, although not consistently at an optimal level. From a management perspective, this finding reflects staffing adequacy as an organizational resource that supports task distribution and workload regulation (Bakker & de Vries, 2021; Boxall et al., 2012).

Meanwhile, the mean workload score indicates that ATCs experience relatively high workload levels. This result is consistent with previous research emphasizing that air traffic control tasks involve high cognitive demands, time pressure, and sustained attention, which contribute to elevated workload perceptions (Wickens et al., 2015; Young et al., 2015).

The normality test results (Table 2) indicate that the regression residuals do not fully meet the assumption of normal distribution.

Table 2. Normality Test Results (Kolmogorov–Smirnov)

Statistic	Value
N	**64**
Test Statistic	**0.102**
Asymp. Sig. (2-tailed)	**0.012**

Source: SPSS output

However, in management and social science research, linear regression is considered robust to moderate deviations from normality, particularly when sample sizes exceed 30 observations (Hair et al., 2019). Therefore, the data were deemed suitable for further regression analysis.

The linearity test results (Table 3) show no significant deviation from linearity, indicating that the relationship between ATCA availability and ATC workload can be appropriately modeled using a linear regression approach. This finding supports the use of linear models in examining relationships between organizational resources and workload outcomes(Bakker & de Vries, 2021).

Table 3. Linearity Test Results

Source	F	Sig.
Linearity	0.078	0.729
Deviation from Linearity	1.206	0.301

Source: SPSS output

The regression results (Table 4) indicate that the availability of Air Traffic Controller Assistants has a statistically significant effect on the workload of Air Traffic Controllers ($p < 0.05$). This finding supports the hypothesis that support staffing functions as an organizational resource influencing workload experiences.

Table 4. Simple Linear Regression Results

Variable	B	Std. Error	t	Sig.
Constant	32.750	3.746	8.743	0.000
ATCA Availability	0.270	0.117	2.311	0.024

Source: SPSS output

From a human resource management perspective, this result aligns with the job demands–resources framework, which posits that organizational resources can mitigate the effects of high job demands on employee workload and strain (Bakker & de Vries, 2021). The presence of ATCAs may reduce non-core task demands, allowing ATCs to focus more effectively on primary control activities.

Table 5. Model Summary

R	R Square	Adjusted R Square
0.282	0.080	0.065

Source: SPSS output

The coefficient of determination (Table 5) shows that ATCA availability explains approximately 8% of the variance in ATC workload. Although the explanatory power is modest, this result is consistent with prior studies

indicating that workload in safety-critical environments is influenced by multiple interacting factors, including organizational, technical, and environmental conditions (Hancock & Meshkati, 2019; ICAO, 2002).

Overall, the findings demonstrate that while ATCA availability significantly influences ATC workload, it represents one component of a broader workload management system. Similar conclusions have been reported in organizational research, which emphasizes that staffing adequacy contributes to workload regulation but does not operate in isolation from other job and environmental factors (Podsakoff et al., 2007).

From a managerial standpoint, these results reinforce the importance of integrating staffing support strategies with other organizational and operational measures to achieve effective workload management in complex service organizations.

The coefficient of determination (Table 5) shows that ATCA availability explains approximately 8% of the variance in ATC workload. In this study, the independent variable (X) is the number of Air Traffic Controller Assistants (ATCA), which is defined as the number of assistant personnel assigned to support an Air Traffic Controller (ATC) during a single operational shift. This variable is measured through several indicators that reflect the level of operational support provided to ATCs.

Overall, the findings of this study demonstrate that the availability of ATCAs has a significant influence on ATC workload, as the presence of assistants can help reduce certain administrative and supporting tasks that are not directly related to the core function of air traffic control. Therefore, the greater the adequacy of the number and role of ATCAs, the greater the potential reduction in ATC workload through a more effective distribution of tasks.

Overall, the findings demonstrate that while ATCA availability significantly influences ATC workload, it represents one component of a broader workload management system. Similar conclusions have been reported in organizational research, which emphasizes that staffing adequacy contributes to workload regulation but does not operate in isolation from other job and environmental factors (Podsakoff et al., 2007).

From a managerial perspective, these results highlight the importance of integrating human resource management strategies, particularly the deployment of ATCAs, with other operational and organizational policies in order to achieve effective workload management within complex and safety-oriented air traffic service systems.

CONCLUSION

This study examined the effect of Air Traffic Controller Assistant (ATCA) availability on the workload of Air Traffic Controllers (ATCs) from an organizational and human resource management perspective. The findings indicate that ATCA availability has a statistically significant effect on ATC workload, suggesting that staffing support functions as an organizational resource that contributes to workload regulation in safety-critical work environments.

Although the magnitude of the effect is moderate, the results reflect the operational reality of air traffic control, where workload is shaped by multiple interacting factors beyond staffing alone. This finding reinforces the view that workload in complex service organizations cannot be fully addressed through technical or operational measures only, but must also be managed through organizational and human resource strategies. Within this context, ATCAs should be understood not merely as operational assistants, but as part of a broader staffing system that supports sustainable performance.

From a theoretical perspective, this study extends the application of workload and Job Demands–Resources frameworks by empirically demonstrating the role of staffing support as a job resource in a safety-critical organizational setting. By integrating an HRM lens into workload analysis, the study contributes to the management literature by highlighting how organizational decisions regarding support roles can influence perceived workload outcomes.

Practically, the findings suggest that air navigation service providers should consider ATCA availability as a strategic element of workforce planning and workload management. Optimizing the deployment and consistency of ATCAs may help organizations mitigate excessive workload, support controller performance, and enhance the sustainability of operations under increasing traffic demands. Future research is encouraged to incorporate additional

organizational variables and longitudinal designs to further explore workload dynamics in complex and safety-critical organizations.

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