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# The Role of ATC Simulation Training in Enhancing Controllers Competence for Abnormal Situations at JATSC

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***Abstract***

*Aviation safety is a top priority in the complex and high-risk aviation industry. Air Traffic Controllers (ATCs) are vital in maintaining safety by managing air traffic and responding effectively to abnormal situations such as adverse weather, equipment failure, or communication disruptions. This study aims to analyze the role of ATC simulation training in enhancing ATC competence, particularly in managing abnormal situations at the Jakarta Air Traffic Service Centre (JATSC). A quantitative descriptive-correlational approach was employed, involving 81 ATCs who had completed simulator training within the past two years. Data were gathered through Likert-scale questionnaires, interviews, observations, and documentation, and analyzed using Pearson correlation and multiple linear regression tests. The results indicate that simulation training significantly contributes to improving ATCs' technical, cognitive, and affective competencies, including decision-making, situational awareness, operational communication, and stress management. These findings highlight the importance of simulation-based learning as an effective method to strengthen ATC readiness and operational performance. The study provides valuable insights for curriculum enhancement at JATSC and serves as a reference for policy formulation aimed at reinforcing aviation safety at the national level*

***Keywords: ATC, Simulation Training, Competence, Situational Awareness, Aviation Safety***

## INTRODUCTION

The aviation industry, characterized by its complexity and high level of operational risk, places safety as a fundamental and non-negotiable principle. Among the key personnel directly responsible for ensuring aviation safety are Air Traffic Controllers (ATCs), who manage the flow of air traffic to guarantee safe takeoffs, flights, and landings. ATCs are required to make rapid and accurate decisions while maintaining high levels of concentration and situational awareness, particularly in abnormal conditions such as adverse weather, technical failures, or communication disruptions. The increasing volume of air traffic within Indonesian airspace, especially at the Jakarta Air Traffic Service Centre (JATSC), significantly elevates the workload and operational challenges faced by ATCs.

Abnormal situations can occur unpredictably and require ATCs to respond swiftly and effectively. Such competence extends beyond procedural knowledge it encompasses cognitive, affective, and psychomotor skills that must be continuously developed through systematic training and simulation-based exercises. Simulation training provides a safe, realistic environment that enhances decision-making, situational awareness, and stress management without compromising flight operations. According to ICAO (2016), simulator-based training significantly improves accuracy, response speed, and confidence in handling emergencies, while Eurocontrol (2021) and Schmidt et al. (2022) highlight its role in reducing operational errors and fostering experiential learning. Similarly, Harris (2021) emphasizes that regular simulation exercises can reduce stress and enhance communication efficiency among ATCs.

Based on these considerations, this study aims to analyze the role of ATC simulation training in enhancing the competence of Air Traffic Controllers at JATSC, particularly in managing abnormal flight situations. The research questions addressed include:

1. Does ATC simulation training significantly improve ATC competence in handling abnormal situations at JATSC?
2. What is the extent of the influence of simulation training on ATC competence enhancement at JATSC?

The purpose of this research is to evaluate and explain the effectiveness of simulation-based training in improving the professional competence of ATCs. The findings are expected to serve as a reference for improving training curricula and policies related to aviation safety management in Indonesia.

## RESEARCH METHODS

This study applied a quantitative research design with a descriptive-correlational approach, aimed at analyzing the relationship between ATC simulation training and the enhancement of Air Traffic Controller (ATC) competence in handling abnormal situations at the Jakarta Air Traffic Service Centre (JATSC). The quantitative approach was selected to allow statistical testing of the relationship between training intensity, simulator use, and ATC competence through measurable indicators.

### Research Design

The study adopted a correlational design, which identifies the strength and direction of the relationship between two independent variables training ($X_1$) and simulator use ($X_2$) and the dependent variable, ATC competence (Y). Statistical analyses included Pearson correlation and multiple linear regression, which determine the extent to which training and simulator usage influence competence simultaneously or independently (Sugiyono, 2016; Janie, 2012).

### Population and Sampling

The population consisted of 436 ATCs working at JATSC under AirNav Indonesia. Sampling used the simple random sampling technique to ensure representativeness. Based on the Slovin formula with a 10% margin of error, the minimum sample size was 81 respondents, increased to 89 to anticipate dropouts.

### Variables and Operational Definitions

1. Independent Variables:
   a. Training ($X_1$) frequency, duration, and relevance of ATC training activities (ICAO, 2016).
   b. Simulator Use ($X_2$) frequency of simulator sessions, diversity of training scenarios (normal and abnormal), and type of simulator used (Eurocontrol, 2021).
2. Dependent Variable: ATC Competence (Y) measured through decision-making ability, situational awareness, operational communication, and stress management (EASA, 2020).

### Data Collection Techniques

Data were obtained using:

1. Questionnaires Likert-scale questions to quantify ATC perceptions of training and competence.
2. Observations non-participatory observation of simulator sessions.
3. Documentation Review analysis of training records, simulator logs, and competence assessments (Sugiyono, 2016).

### Data Analysis Techniques

The research employed:

1. Pearson Correlation Test to assess linear relationships between variables.
2. Multiple Linear Regression to determine the simultaneous and partial effects of training and simulator use on ATC competence.

Both analyses used a significance level of 0.05, and model validity was tested through classic assumption tests (normality, multicollinearity, and heteroskedasticity) to ensure reliability of results.

**Research Location and Duration**

The study was conducted at Jakarta Air Traffic Service Centre (JATSC), located within Soekarno-Hatta International Airport, Tangerang, Banten. The research spanned eight months from data collection to analysis and reporting at both JATSC and the Indonesian Aviation Polytechnic (PPI Curug).

## RESULT AND DISCUSSION

This research investigated the role of ATC simulation training in enhancing the competence of Air Traffic Controllers (ATCs) in handling abnormal flight situations at the Jakarta Air Traffic Service Centre (JATSC). A total of 106 respondents participated, all of whom had undergone simulation-based training within the past two years. JATSC represents Indonesia's busiest and most complex airspace, operating under ICAO standards with a continuous focus on maintaining operational safety and human performance excellence.

Given this context, the study's analysis concentrated on three principal variables: training ($X_1$), simulator use ($X_2$), and ATC competence (Y). Each variable was measured using Likert-scale indicators and subsequently processed through descriptive and inferential statistical analysis.

**Descriptive Analysis of Key Variables**

Table 1. Descriptive Analysis of Training, Simulator, and Competence Variables

| Variable | N | Min | Max | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Training ($X_1$) | 106 | 5.00 | 24.00 | 18.08 | 3.61 |
| Simulator ($X_2$) | 106 | 9.00 | 25.00 | 17.43 | 3.42 |
| ATC Competence (Y) | 106 | 10.00 | 25.00 | 20.43 | 2.39 |

The results reveal that ATC competence obtained the highest mean score (20.43), followed by training (18.08) and simulator use (17.43). The relatively small standard deviation of the competence variable indicates that respondents shared similar perceptions of their professional abilities. This homogeneity reflects the effectiveness of JATSC's internal performance standards and supervision systems, which ensure consistent operational competence among controllers with different experience levels.

Conversely, wider score distributions in the training and simulator variables suggest diversity in exposure, duration, and quality of training experiences. While most respondents acknowledged regular participation in simulation-based training, some reported limited access or shorter durations. This variability indicates a potential gap in simulation frequency across units, reinforcing the need for more equitable training distribution.

The high competence mean further indicates that ATCs perceive themselves as well-prepared to handle abnormal operational conditions. This includes abilities such as decision-making under pressure, situational awareness, procedural mastery, and communication accuracy all critical elements of aviation safety as emphasized by ICAO (2016) and EASA (2020).

**Normality and Multicollinearity Testing**

Before conducting regression analysis, assumption tests confirmed that the dataset met analytical prerequisites. The residual normality test displayed a symmetrical bell-shaped distribution (Figure 1) with mean ≈ 0 and standard deviation close to 1, validating the use of parametric regression methods. The P-P Plot also showed that data points followed the diagonal line with minimal deviation, confirming that residuals were normally distributed.

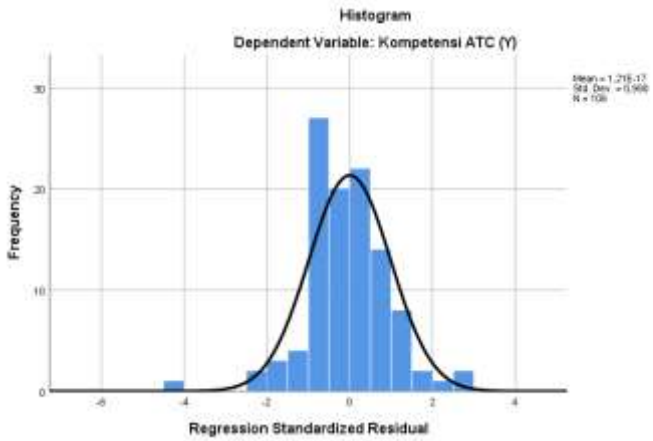


Figure 1. Residual Normality Distribution

Meanwhile, the multicollinearity test indicated that the tolerance values for both independent variables were above 0.10 and the Variance Inflation Factor (VIF) values were below 10. This demonstrates that training and simulator variables are statistically independent. Substantively, this means that while both contribute to competence, they represent distinct dimensions of professional development one cognitive and procedural (training), and the other experiential and adaptive (simulation) (Çınar & Tuncal, 2024).

**Regression and Correlation Findings**

The regression results indicate that training and simulator use significantly contribute to ATC competence, both individually and collectively. The model demonstrated a strong positive correlation coefficient, confirming a direct and consistent relationship among the variables.

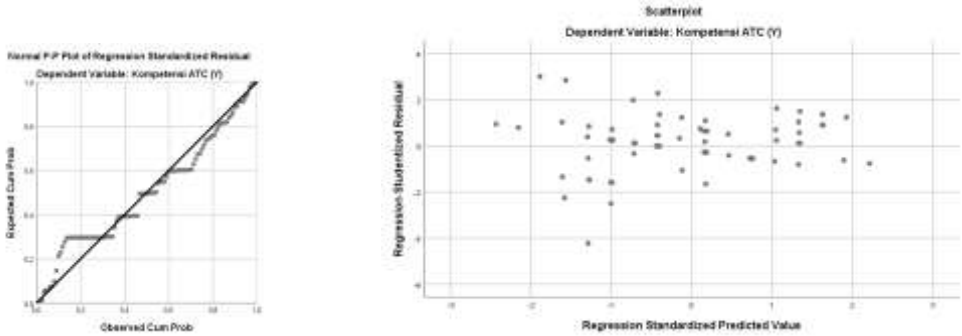


Figure 2. Regression Relationship between Training, Simulation, and Competence *(Graph showing rising linear trend lines from Training → Competence and Simulation → Competence.)*

In practical terms, each incremental improvement in simulator engagement or training quality corresponds with measurable increases in competence scores. This finding aligns with Bridges III (2016) and Eurocontrol (2021), who found that repetitive exposure to simulation enhances retention of procedural accuracy, situational awareness, and real-time judgment.
The regression model can be summarized as:

$$Y=1.721+0.617X_1+0.482X_2$$

Where both coefficients are positive and significant at $p < 0.05$. This suggests that competence is shaped jointly by training and simulation experiences, validating the study's core hypothesis.

**Integrated Interpretation**

The combination of descriptive and regression findings reinforces the proposition that simulation-based training functions as an integral component of ATC competence development. While training strengthens theoretical comprehension and procedural reliability, simulation bridges the gap between conceptual understanding and operational execution.

Controllers who engage more frequently in simulator sessions report higher readiness levels when confronted with unexpected scenarios such as communication failure, weather disturbances, or technical anomalies. This echoes the ICAO Competency-Based Training and Assessment (CBTA) principle, which emphasizes experiential learning through structured performance practice (ICAO, 2016).

The data also revealed that ATCs with longer service durations tend to score higher in competence, even when their simulator exposure is limited. This indicates that practical experience complements formal training, fostering intuitive decision-making and adaptive judgment under time constraints. Nevertheless, reliance solely on experience may create overconfidence if not continuously supported by updated simulation practice a condition observed in several aviation safety reports (Harris, 2021; Eurocontrol, 2021).

**Discussion in Context**

The study corroborates prior research asserting that simulation enhances the technical and cognitive dimensions of ATC performance. For instance, Fridyatama et al. (2023) observed that simulated ATC environments in Indonesia improved communication precision and adherence to standard phraseology, while Çınar & Tuncal (2024) demonstrated that workload management improves with consistent exposure to abnormal traffic simulations.

In the context of JATSC, these findings emphasize simulation as not only a training tool but a strategic safety mechanism that directly influences system reliability. The relatively homogeneous competence levels suggest that organizational standards ensure a baseline of operational proficiency. However, the variance in simulator exposure implies a need for systematic training rotation and performance-based scheduling to ensure equal learning opportunities across all personnel.

Furthermore, the findings highlight how experiential repetition through simulation strengthens stress resilience and response coordination skills essential in mitigating human error during real-world operations. As noted by Schmidt et al. (2022) repeated exposure to controlled stress environments enables ATCs to maintain composure and consistency, even under high workload conditions.

**Practical Implications for JATSC and AirNav Indonesia**

The empirical evidence suggests several actionable insights for training policymakers:

1. Enhancement of Simulator Integration:
   Incorporate more complex, multi-sector, and cross-unit scenarios into simulation curricula to mirror real-world operational complexity.
2. Instructor Development:
   Train instructors to facilitate interactive debriefing sessions that convert simulator performance into targeted behavioral improvement.
3. Standardization of Training Access:
   Implement balanced scheduling to ensure all ATCs undergo equivalent simulator cycles annually, reducing disparities in exposure.

4. Continuous Evaluation: Establish a feedback mechanism that aligns simulation results with performance appraisals, ensuring competency development remains measurable and adaptive.

By implementing these recommendations, JATSC can strengthen its institutional framework for maintaining consistent ATC competence across all operational sectors.

## CONCLUSION

This study concludes that ATC simulation training plays a crucial role in enhancing the competence of Air Traffic Controllers (ATCs) at the Jakarta Air Traffic Service Centre (JATSC), particularly in managing abnormal flight situations. Both structured training programs and consistent simulator use significantly improve ATCs' technical, cognitive, and affective abilities, including decision-making, situational awareness, communication, and stress management. The results affirm that simulation-based learning effectively strengthens operational readiness and safety performance, underscoring the importance of maintaining regular, scenario-diverse simulation sessions to ensure high professional standards and consistent safety outcomes within Indonesia's air traffic management system.

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