Mental Workload Assessment of Aviation Security Personnel Using NASA-TLX Method at Djalaluddin Gorontalo Airport

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ABSTRACT

Aviation safety and security are vital aspects of airport operations, with Aviation Security (AVSEC) personnel serving as the frontline protectors. High mental workload, particularly among Junior and Senior license levels, can affect performance and psychological stability. This study aims to assess mental workload levels based on AVSEC license classification and propose strategies for mitigation.
A descriptive quantitative approach was applied using the NASA-TLX method, which evaluates six dimensions: Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration. Questionnaires were distributed to 69 AVSEC personnel at Djalaluddin Gorontalo Airport, categorized into Basic, Junior, and Senior license levels. Raw average scores were calculated and compared across groups.
Results showed that Basic personnel scored 42.05 (moderate), while Junior and Senior scored 88 and 84 respectively (very high). Junior personnel were most burdened by Physical Demand and Effort, while Senior personnel experienced higher Mental and Temporal Demands. Recommended strategies include promoting qualified Basic staff, implementing 20/40-minute X-ray operator rotations, stress management training, and regular evaluations using NASA-TLX.

Keywords: *Mental workload, AVSEC, NASA-TLX, Djalaluddin Airport*

1. INTRODUCTION

Air transportation is a critical infrastructure for archipelagic nations such as Indonesia, where geographical dispersion presents significant challenges to interregional connectivity. Airports serve as strategic hubs that facilitate mobility, economic exchange, and public service delivery (Kusumawardhani, 2023). Djalaluddin Gorontalo Airport, located in Gorontalo Regency, plays a vital role in supporting domestic and international travel, contributing to regional development and tourism.

Aviation safety and security are non-negotiable priorities in airport operations. According to the Indonesian Ministry of Transportation Regulation No. PM 93 of 2016, flight safety must be ensured through compliance with airspace utilization, aircraft operations, airport infrastructure, and supporting facilities. Aviation Security (AVSEC) personnel are central to this mission, tasked with screening passengers, crew, and staff to prevent unlawful interference (Sulistyo & Suprapti, 2023). Their duties require sustained concentration, rapid decision-making, and emotional resilience, especially under shift-based schedules that operate continuously.

Mental workload refers to the cognitive demands placed on individuals during task execution. When excessive, it can lead to fatigue, stress, and performance degradation (Wulanyani, 2013). In high-risk environments like airports, even minor lapses in attention can have serious consequences. The NASA Task Load Index (NASA-TLX), developed by Hart and Staveland (1988), is a validated tool for assessing subjective mental workload across six dimensions: Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration.

Previous studies have shown that AVSEC personnel frequently experience moderate to high mental workload, particularly in dimensions related to time pressure and task complexity (Satriadi et al., 2022; Octaviaji & Hidayati, 2024). Factors such as staffing shortages, uneven task distribution, and lack of rotation systems exacerbate these pressures. At Djalaluddin Gorontalo Airport, operational challenges include imbalanced license levels among AVSEC staff, double job assignments, and limited availability of qualified X-ray operators. The absence of a structured 20/40-minute rotation system, as mandated by KM 39/2024, further increases fatigue and reduces vigilance.

This study aims to identify and describe the mental workload levels of AVSEC personnel at Djalaluddin Gorontalo Airport using the NASA-TLX method. It also seeks to analyze strategic interventions to reduce workload, focusing on the most affected dimensions. The findings are expected to contribute to human resource management practices in aviation, supporting safer and more sustainable airport operations.

2. METHODOLOGY

2.1. Research Design

This study employs a quantitative descriptive method to measure the mental workload of AVSEC personnel at Djalaluddin Airport, Gorontalo. The NASA-TLX questionnaire is used as the primary instrument, generating numerical data across six dimensions of mental workload. The research process includes problem identification, instrument development, data collection and processing, analysis, and conclusion drawing. The workflow of the research is illustrated in the following flowchart.

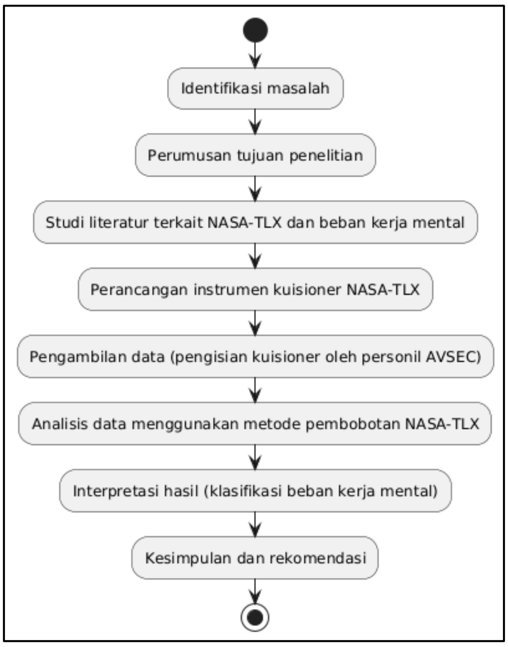

Figure 1. Research Flowchart Design

Based on Figure 1, the following are brief explanations of each research stage:

1. **Problem Identification:** Identifying key issues at the research site, such as passenger congestion at the Security Checkpoint (SCP), limited availability of x-ray operators, and the occurrence of double job roles that increase AVSEC personnel's workload.
2. **Formulation of Research Objectives:** Defining the objective to measure the mental workload of AVSEC personnel as a basis for improving operational efficiency.
3. **Literature Review:** Examining the NASA-TLX framework and related concepts of mental workload to establish the methodological foundation of the study.
4. **Instrument Design:** Developing the NASA-TLX questionnaire based on theoretical insights to assess personnel perceptions of mental workload.
5. **Data Collection:** Distributing the questionnaire to AVSEC personnel to gather firsthand data on their work experiences.
6. **Data Analysis:** Processing the data using NASA-TLX weighting methods to determine mental workload levels across six dimensions.
7. **Result Interpretation:** Interpreting the analysis to identify work areas with high risk of stress or fatigue.
8. **Conclusion and Recommendations:** Drawing conclusions and offering suggestions, such as increasing staffing or optimizing work systems to reduce mental strain.

2.2. Research Location

This study was conducted at Djalaluddin Airport, a Class I airport located in Tibawa District, Gorontalo Regency, approximately 30 km from downtown Gorontalo. The airport is situated at coordinates 00°38'17" N and 122°51'07" E, with an elevation of approximately 18 meters above sea level. The location was selected as it serves as the primary operational area for AVSEC personnel involved in this research.

2.3. Research Object

The object of this study is the Aviation Security (AVSEC) personnel at Djalaluddin Airport, Gorontalo. AVSEC is responsible for ensuring aviation safety through passenger screening, baggage inspection, and area surveillance—tasks that demand high concentration and precision. They were selected due to the mentally demanding nature of their work. Mental workload levels were assessed using the NASA-TLX method to obtain an objective overview of the pressure experienced during daily operations.

2.4. Data Collection Technique

Data were collected using the NASA-TLX questionnaire to facilitate the measurement of mental workload among AVSEC personnel at Djalaluddin Airport, Gorontalo. This method was chosen for its alignment with the research objectives and its ability to support objective quantitative analysis.

2.5. Research Instrument

According to Sugiyono (2017), a research instrument is a tool used to measure observed natural or social phenomena. In this study, the instrument used is the NASA-TLX questionnaire, designed to assess mental workload across six key dimensions: mental demand, physical demand, temporal demand, performance, effort, and frustration level. The questionnaire was distributed to AVSEC personnel to obtain accurate data, with item construction guided by an instrument blueprint.

2.6. Data Analysis Technique

Data obtained through the NASA-TLX method were analyzed descriptively to determine the average mental workload of AVSEC personnel at Djalaluddin Airport, Gorontalo. Statistical analysis was conducted to compare workload levels between personnel with high and low competence, and to assess whether the workload remained within normal limits. Additionally, the NASA-TLX dimensions contributing most to mental workload were identified to support recommendations for improving AVSEC personnel competence.

Mental workload assessment using the NASA-TLX method involves six key steps (Pradhana & Suliantoro, 2018):

1. **Weighting**: Respondents compare 15 pairs of workload dimensions to identify the most dominant factor. The resulting weights serve as the basis for final score calculation.

2. **Rating:** Each dimension is rated on a scale from 0 to 100, reflecting the respondent's perceived workload intensity.

3. **Weighted Score Calculation:** The weighted score for each dimension is obtained by multiplying its weight by the corresponding rating. The formula used is:

$$\text{Weighted Score} = \text{Weight x Rating} \quad (1)$$

4. **Weighted Workload Level (WWL):** WWL is calculated by summing the weighted scores of all six dimensions. The formula used is:

$$\text{WWL} = \Sigma \text{ (Nilai Produk)} \quad (2)$$

5. **NASA-TLX Final Score:** The final score is derived by dividing the total WWL by 15, representing the number of dimension pairings. The formula used is:

$$Skor\ NASA - TLX = \frac{\Sigma\ (\text{Produk})}{15} \quad (3)$$

6. **Score Interpretation:** The score indicates the level of mental workload experienced:

- 0–20: Very low
- 21–40: Low
- 41–60: Moderate
- 61–80: High
- 81–100: Very high

This structured approach enables researchers and practitioners to identify the most influential workload dimensions and design targeted interventions to mitigate mental strain.

2.7. Place and Time of Research

The study was conducted at Djalaluddin Airport Gorontalo (Class I), specifically within the operational area of Aviation Security (AVSEC) personnel. Data collection took place over a six-month period, starting in early January.

3. RESULT

3.1 Respondent Characteristics

This study involved 69 Aviation Security (AVSEC) personnel at Djalaluddin Airport Gorontalo. Respondents were categorized based on their license level, which reflects differences in responsibilities, task types, and mental workload.

Of the total respondents:

- 12 held a **Senior AVSEC License**
- 13 held a **Junior AVSEC License**
- 44 held a **Basic AVSEC License**

This composition mirrors the actual personnel structure, with Basic license holders forming the majority due to their direct involvement in passenger and baggage screening operations.

3.2. Data Collection Results

Data were collected using a Google Form-based questionnaire, chosen for its efficiency, accessibility, and ease of data processing. A total of 69 AVSEC personnel at Djalaluddin Airport Gorontalo participated, consisting of 44 Basic License holders, 13 Junior, and 12 Senior.

This respondent distribution reflects the actual field composition and serves as the foundation for subsequent NASA-TLX analysis, including weighting, rating, and workload scoring.

3.3. Weighting Results

The weighting was conducted through pairwise comparisons across six dimensions of mental workload. Table 1 presents the average weights for each dimension, categorized by AVSEC license levels: Basic, Junior, and Senior.

Table 1. Weighting Results

Dimensi	***Basic* AVSEC**	**Junior AVSEC**	**Senior Avsec**
KM	2.52	2.31	2.83
KF	2.55	2.77	2.67
KW	2.50	2.31	2.33
P	2.64	2.46	2.75
TU	2.39	2.69	1.92
TF	2.41	2.46	2.50
Total	15	15	15

Based on Table 1, the results indicate distinct dominant dimensions across groups:

- **Basic AVSEC**: dominant in *Performance* (2.64) and *Physical Demand* (2.55)
- **Junior AVSEC**: dominant in *Physical Demand* (2.77) and *Effort* (2.69)
- **Senior AVSEC**: dominant in *Mental Demand* (2.83) and *Performance* (2.75)

These differences reflect variations in perceived mental workload based on license level and serve as a foundation for further analysis in calculating overall NASA-TLX scores.

3.4. NASA-TLX Rating Results

The second stage of NASA-TLX data processing involved rating each workload dimension on a scale of 0–100. Table 4.2 presents the average ratings given by AVSEC personnel across license levels.

Table 2. Rating Results

Dimensi	**Basic AVSEC**	**Junior AVSEC**	**Senior Avsec**
KM	34,5	83,5	86,3
KF	38,2	93,8	86,3
KW	41,6	84,6	87,5
P	48,5	89,2	85
TU	50,9	89,2	86,3
TF	38,5	86,9	87,1

Based on Table 2, it is found that:

- Basic AVSEC efforts have the highest score (50.9) and Mental Demand is the lowest (34.5).
- Junior AVSEC shows a significantly higher overall rating, with Physical Demand being the most burdensome (93.8).
- Senior AVSEC reports consistently high ratings across all dimensions, with Temporal Demand rated the highest (87.5).

These results indicate a clear trend: higher licensing levels correlate with increased perceived mental workload. This emphasizes the need for targeted strategies to manage workload demands at various levels of AVSEC personnel.

3.5. NASA-TLX and WWL Calculation Process

The NASA-TLX calculation consists of two main stages: dimension weighting and rating, followed by computation using the *Weighted Workload Level* (WWL) method. The formula applied is:

$$WWL\ per\ dimension = \left(\frac{Dimension\ Weight}{Total\ Weight}\right) \times Rating$$
$$Total\ WWL = \Sigma WWL\ per\ dimension \qquad (4)$$

As an example, the WWL calculation for the Basic AVSEC group is as follows:

1. **Weighted Score Calculation:** Each dimension is calculated by multiplying the weighting value obtained from the weighting stage with the rating value provided by respondents. The calculation results for Basic AVSEC personnel are presented in Table 3.

Table 3. Weighted Workload Calculation for Basic AVSEC

Dimension	**Weight**	**Rating**	**Product (Weight x Rating)**
KM	2,52	34,5	86,94
KF	2,55	38,2	97,41
KW	2,50	41,6	104,00
P	2,64	48,5	128,04
TU	2,39	50,9	121,65
TF	2,41	38,5	92,78

2. **Total WWL Calculation:** The Weighted Workload Level (WWL) is obtained by summing all weighted scores across the six dimensions:

$$\begin{aligned} &WWL = \Sigma \text{ Weighted Scroes} \\ &WWL = \\ &86.94+97.41+104.00+128.04+121.65+92.78 \\ &WWL = 620,82 \end{aligned} \quad (5)$$

3. **Final NASA-TLX Score Calculation:** The final NASA-TLX score is calculated by dividing the total WWL by a constant value of 15, which represents the total number of paired comparisons in the weighting stage:

$$\begin{aligned} Skor\ NASA - TLX &= \frac{\Sigma\ (\text{Produk})}{15} \\ Skor\ NASA - TLX &= \frac{620{,}82}{15} \\ Skor\ NASA - TLX &= 41{,}39 \end{aligned} \quad (6)$$

After completing all stages—from weighting and rating to weighted score calculation—the total WWL of 620.82 is obtained. This value is then divided by the constant 15, resulting in a final NASA-TLX score of 41.39. This score indicates that the mental workload experienced by Basic AVSEC personnel falls within the "moderate" category.

3.6. Mental Workload Classification

Based on NASA-TLX calculations, the mental workload levels of AVSEC personnel are classified into three categories: low, moderate, and very high.

Table 4. NASA-TLX Calculation Results

License	NASA-TLX score	Category
Basic Avsec	42,05	Currently
Junior Avsec	88	Very High
Senior Avsec	84	Very High

Based on Table 4, these results reflect a clear escalation in mental workload across license levels. Junior AVSEC personnel face intense operational and physical demands, while Senior AVSEC personnel experience significant cognitive pressure due to supervisory and decision-making responsibilities. This finding highlights the urgent need for managerial interventions to mitigate mental workload and ensure optimal performance and operational safety at Djalaluddin Airport, Gorontalo.

4. DISCUSSION

This study reveals a significant disparity in mental workload levels among AVSEC personnel at Djalaluddin Airport, Gorontalo, based on license classification. NASA-TLX scores indicate that Basic AVSEC personnel fall within the moderate category (42.05), while Junior and Senior AVSEC personnel are categorized as very high (88 and 84, respectively). These findings suggest that higher license levels are associated with increased cognitive and operational demands.

Junior AVSEC personnel reported the highest workload in the dimensions of Physical Demand and Effort, reflecting the intensity of physical tasks and mental exertion required in field operations. In contrast, Senior AVSEC personnel experienced greater strain in Mental Demand and Temporal Demand, consistent with their supervisory roles and time-sensitive decision-making responsibilities. This supports Sritomo's (2008) assertion that task variation directly influences mental workload levels.

The comparison across license levels highlights an imbalance in workload distribution. Junior AVSEC personnel bear the brunt of physical and operational tasks, while Senior AVSEC personnel face elevated mental and temporal pressures. Basic AVSEC personnel, whose duties are procedural and closely supervised, experience relatively lower mental workload. Such disparities may lead to chronic work stress if not addressed through appropriate managerial strategies (Satriadi et al., 2022).

To mitigate these risks, the study recommends several strategic interventions: promoting qualified Basic AVSEC personnel to Junior level to balance task allocation, implementing a 20/40-minute X-ray operator rotation system in accordance with KM 39 of 2024, conducting stress management training, and performing regular evaluations using the NASA-TLX method. Routine assessments not only help monitor current workload conditions but also serve as a basis for decision-making in work schedule adjustments and human resource development.

Overall, the findings underscore that mental workload is a critical factor influencing AVSEC performance and operational safety. Systematic and data-driven workload management is essential to foster a healthy, secure, and productive working environment in the aviation sector.

AUTHORS' CONTRIBUTIONS

The author was solely responsible for all stages of this research, from problem formulation and data collection to analysis and manuscript preparation. Specifically, the contributions include:

1. Research design: Formulating objectives, conceptual framework, and methodology using SEM-PLS.
2. Development of socialization media: Designing and implementing QR Code-based tools to enhance aviation safety awareness.

3. Data collection: Conducting field observations and distributing instruments to AVSEC personnel.
4. Data analysis: Processing and interpreting data using quantitative approaches and statistical software.
5. Manuscript writing: Composing the article, including the introduction, literature review, results, and discussion.
6. Revision and editing: Refining the manuscript based on feedback from supervisors and journal reviewers.

The author affirms that no other individuals contributed to the writing of this article. All processes were conducted independently, in accordance with ethical standards for research and academic publication.

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REFERENCES

[1] Kusumawardhani, O. B. (2023). Beban kerja terhadap motivasi kerja perawat rawat inap di rumah sakit. *Jurnal Manajemen Dayasaing*, *25*(2), 71–78.

[2] Octaviaji, M. R., & Hidayati, R. A. (2024). Analisis Beban Kerja Mental Karyawan Di Laboratorium Pt. Abc Menggunakan Metode Nasa-Tlx. *Komitmen: Jurnal Ilmiah Manajemen*, *5*(1), 44–53. https://doi.org/10.15575/jim.v5i1.33590

[3] Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 93 Tahun 2016 Tentang Program Keselamatan Penerbangan (2016).

[4] Pradhana, C. A., & Suliantoro, H. (2018). Analisis beban kerja mental menggunakan Metode NASA-TLX pada bagian shipping perlengkapan di PT. Triangle Motorindo. *Industrial Engineering Online Journal*, *7*(3).

[5] Satriadi, Puji, A. A., & Syafrizal, E. (2022). Analisis Pengukuran Beban Kerja Mental dengan Metode Nasa Tlx pada Karyawan Divisi Laboraturium PT. Mahato Inti Sawit. *Jurnal Surya Teknika*, *9*(2), 498–502. https://doi.org/10.37859/jst.v9i2.4364

[6] Sritomo, W. (2008). *Ergonomi, Studi Gerak dan Waktu*. Guna Widya.

[7] Sugiyono. (2017). *Metodologi Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta.

[8] Sulistyo Dwi Pamuji, & Suprapti. (2023). Peran Aviation Security (Avsec) Dalam MenunjangKeamanan Penerbangan Di Bandar Udara RahadiOesman Ketapang Kalimantan Barat. *Jurnal Ground Handling Dirgantara*, *5*(1), 14–20.

[9] Wulanyani, N. M. S. (2013). Tantangan dalam Mengungkap Beban Kerja Mental. *Buletin Psikologi*, *21*(2), 80–89.