Design Planning of Ground Run-Up Enclosure Using SketchUp Application at El Tari Airport Kupang

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ABSTRACT

Engine ground run-up activities are a critical component of aircraft maintenance, ensuring engine reliability before returning to operation. However, conducting these procedures in non-designated areas such as runways can pose safety risks and disrupt airport operations. El Tari Airport in Kupang, a hub for ATR 72-600 aircraft maintenance, currently lacks a dedicated facility for this purpose, resulting in run-up operations being conducted on Runway 08 outside regular hours. This condition highlights the need for a planned Ground Run-Up Enclosure (GRE) to enhance safety and operational efficiency.
This study adopts a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The design was developed using SketchUp to produce a realistic three-dimensional visual representation. Data collection involved direct observation and in-depth interviews with Apron Movement Control (AMC) personnel at El Tari Airport, alongside technical and operational analysis. The evaluation phase assessed the effectiveness of the design in supporting safe and efficient engine ground run-up procedures.
The results indicate that the proposed GRE design, covering 3,300 m² and featuring an 8-meter-high, 50-meter-long blast deflector, can safely accommodate ATR 72-600 aircraft. The structure effectively mitigates propeller wash and reduces the risk of foreign object debris (FOD). Expert feedback confirms that the design enhances safety, improves technician workflow, and supports smoother airside operations. This research is expected to serve as a reference for developing aviation safety support facilities at airports across Indonesia, particularly in the eastern region.

Keywords: *Ground Run-Up Enclosure, SketchUp, Aviation Safety, Propeller Wash.*

1. INTRODUCTION

The development of transportation in Indonesia has progressed significantly in response to increasing mobility demands and the geographical challenges of an archipelagic nation. With a total area of 1.905 million km² and thousands of islands stretching from Sabang to Merauke, transportation has become a primary necessity for reaching various regions, especially remote areas that are difficult to access by land or sea (Anto & Plantianti, 2020). In this context, air transportation is considered the most effective mode in terms of time efficiency and accessibility.

Airports play a strategic role as key nodes in the air transportation system, not only serving as points of departure and arrival but also functioning as centers of economic activity and instruments for equitable national development (Haridan et al., 2023). According to the International Civil Aviation Organization (ICAO), an airport is defined as an area of land or water intended for aircraft operations, including takeoff, landing, and movement (ICAO, 2022).

One of the airports with a vital role in eastern Indonesia is El Tari Airport in Kupang, East Nusa Tenggara. Serving as a regional hub, the airport accommodates 30–40 flights per day operated by seven airlines and supports maintenance activities for ATR72-600 aircraft by PT Wings Abadi. However, the airport currently lacks a dedicated facility for engine ground run-up procedures, which are instead conducted on Runway 08 under the supervision of the Apron Movement Control (AMC) unit.

The absence of a designated run-up area increases the workload of AMC personnel and poses potential safety risks, particularly related to Foreign Object Debris (FOD) in maneuvering areas. To ensure operational safety and efficiency, the development of a Ground Run-Up Enclosure (GRUE) is proposed. This facility would provide a controlled environment for engine testing, equipped with safety-supporting systems to minimize operational disruptions and enhance flight safety.

Based on this urgency, the present study aims to design a 3D Ground Run-Up Enclosure using SketchUp software and analyze its potential impact on flight safety at El Tari Airport. Employing a Research and Development (R&D) approach, this research seeks to produce an applicable design that contributes to improved service quality and operational safety at regional airports.

2. METHODOLOGY

2.1. Research Method

This study employs a Research and Development (R&D) approach aimed at producing a design for a Ground Run-Up Enclosure at El Tari Airport in Kupang. The method was selected to align with the research objective: developing a practical, SketchUp-based 3D design that supports operational safety in aviation.

In general, research methodology refers to a scientific approach that is rational, empirical, and systematic—used to obtain and analyze data in order to address the research problem. A rational approach means the process is guided by logical reasoning; an empirical approach ensures that procedures are observable and verifiable; and a systematic approach involves structured, step-by-step execution to produce accountable results (Sugiyono, 2015). These principles form the foundation for conducting research that is both purposeful and beneficial (Handayani, 2020).

2.2. Research Design

This study adopts a Research and Development (R&D) approach, which focuses on product development and testing its effectiveness (Sugiyono, 2015). To guide the development process, the ADDIE model—consisting of Analysis, Design, Development, Implementation, and Evaluation—is used as a systematic and flexible framework for designing the Ground Run-Up Enclosure (Jurianto, 2017). The ADDIE development framework is illustrated in Figure 1. ADDIE Development Stages (Jurianto, 2017):

1. **Analysis:** Identifying problems, examining root causes, and determining appropriate solutions. This may include needs analysis, job analysis, and task analysis.
2. **Design:** Planning development strategies based on the analysis results. This includes defining objectives, learning analysis, and preparing assessment tools.
3. **Development:** Creating the design based on data from the previous stages. In this study, it involves producing a 3D model of the Ground Run-Up Enclosure.
4. **Implementation:** Applying the developed design to assess its feasibility and operational relevance.
5. **Evaluation:** Measuring the effectiveness and efficiency of the design to ensure it meets safety and operational standards.

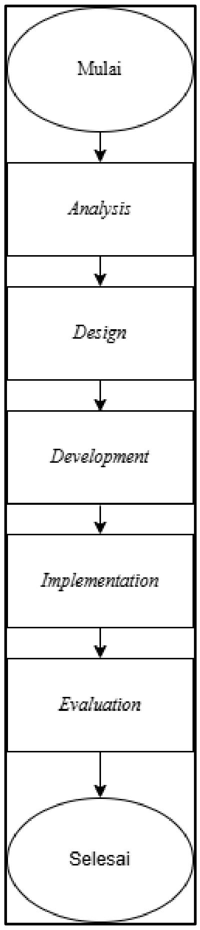

Figure 1. Research Development of ADDIE

2.3. Planning Flow Diagram

The planning flow diagram in Figure 2 illustrates a logical and systematic sequence of thought in the design process. This flowchart outlines the steps from problem identification, needs analysis, and solution formulation to the development of applicable designs and recommendations. The visual serves as a conceptual guide for the development of the Ground Run-Up Enclosure, ensuring a structured and well-directed design process.

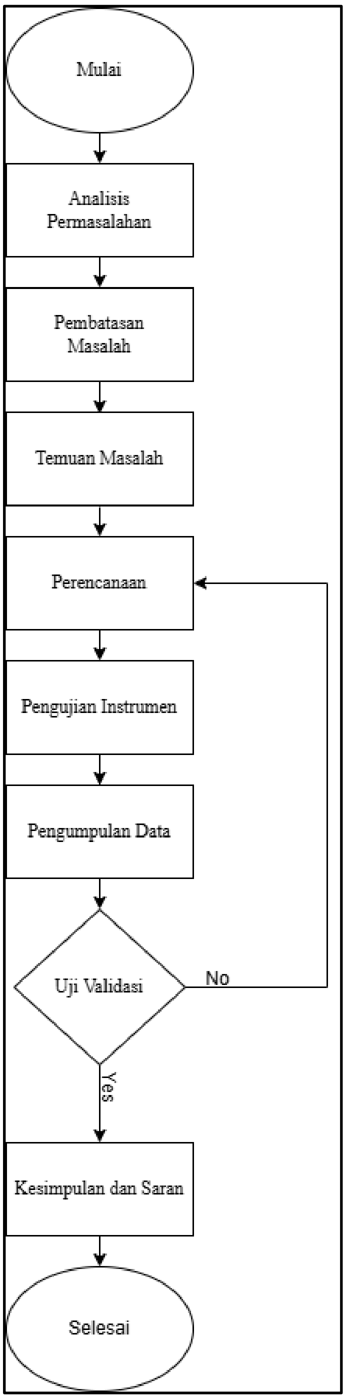

Figure 2. Flowchart of Planning

2.4. Instrument Design

This section outlines the conceptual and technical process of designing the Ground Run-Up Enclosure, along with the supporting components used for visualization.

2.4.1. Instrument Design

The instrument developed in this study consists of a basic Ground Run-Up Enclosure design, created using design software to produce a two-dimensional visual representation. This visualization clarifies the core concept and provides a comprehensive overview of the proposed layout. The selected location is near the apron area of El Tari Airport, chosen for its accessibility and operational convenience for aircraft repositioning prior to engine run-up.

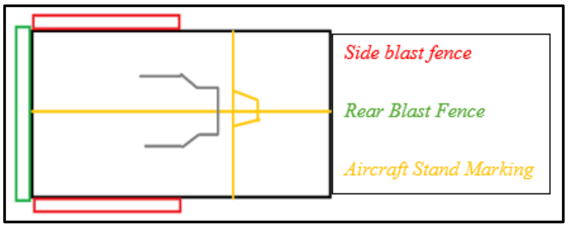

Figure 3. Basic Ground Run-Up Enclosure Design

Figure 4. Ground Run-Up Enclosure Plan

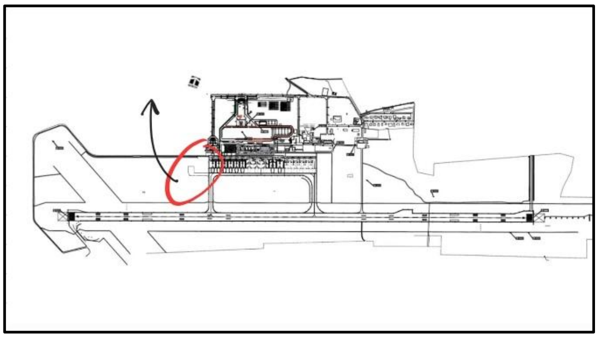

Figure 5. El Tari Airport Layout

2.4.2. Instrument Workflow

Figure 6 presents the flowchart for the application process to use the Ground Run-Up Enclosure. Airlines submit a request to the airport operator. Upon approval, the Apron Movement Control (AMC) unit repositions the aircraft to the designated enclosure area for engine run-up procedures.

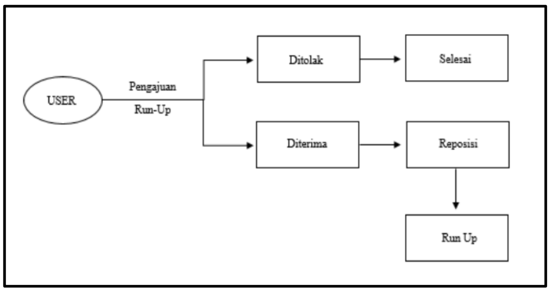

Figure 6. Instrument Workflow

2.4.3. Instrument Components

To support optimal design output, the following components were used:

1. **Hardware**
   Laptop specifications:
   - AMD Ryzen 7 6800H with Radeon Graphics, 3.20 GHz
   - 16 GB RAM
   - Windows 11 Home Single Language
2. **Software**
   - Paint
   - SketchUp

2.5. Design Testing Techniques

Testing is conducted to ensure that the developed system functions properly and aligns with its intended objectives. This process consists of three main stages:

1. **Initial Testing:** Performed after the application design is completed and the system is ready for use. The primary goal is to identify errors or margins of deviation before full implementation. This stage ensures that the system fulfills its core functions optimally.

2. **System Evaluation:** At this stage, users conduct trials to assess whether the system operates according to the design and researcher expectations. If the system meets operational needs and no significant issues are found, it is deemed feasible for implementation.

3. **System Deployment:** This final stage involves the actual use of the system in real operational conditions. The system is considered ready after passing previous testing and evaluation phases, demonstrating stable performance aligned with its development goals.

2.6. Data Collection Techniques

This study employs two primary methods:

1. **Observation:** Direct observation of Ground Run-up procedures at El Tari Airport to obtain factual data (Zunita, 2019).
2. **Interview:** Structured interviews with relevant personnel to gather insights on how the Ground Run-up Enclosure design contributes to aviation safety (Arismunandar).

2.7. Data Analysis Techniques

This study applies a descriptive qualitative method to analyze data obtained through observation and interviews (Alaudin et al., 2023). The analysis is guided by relevant theories to ensure alignment with field conditions (Handayani, 2020).

2.7.1. Qualitative Data Analysis

Based on Miles and Huberman, qualitative data analysis consists of three simultaneous stages:

1. **Data Reduction:** Simplifying and organizing raw data throughout the research process (Miles & Huberman, 1994).
2. **Data Display:** Presenting data systematically in visual or narrative form to support interpretation (Miles, Huberman, & Saldana, 2014).
3. **Conclusion Drawing and Verification:** Identifying patterns and relationships, followed by validation to ensure reliability (Miles & Huberman, 1994).

These components interact continuously and form an integrated cycle throughout the study.

2.7.2. Design Testing Technique

Design testing is conducted through in-depth interviews with aviation operations specialists at El Tari Airport. The data is analyzed inductively by identifying themes, interpreting meaning, and drawing conclusions based on emerging patterns (Sugiyono, 2015).

2.8. Research Location and Period

This research was conducted at El Tari Airport in Kupang during the period of January 6, 2025 to February 28, 2025. The location was selected based on the implementation of On the Job Training (OJT), which served both as a graduation requirement and as a means to assess the trainees' ability to apply their knowledge and skills in a real operational environment.

3. RESULT

3.1. Analysis Results

Based on observations of operational conditions at El Tari Airport in Kupang, it was found that the airport currently lacks dedicated facilities for aircraft maintenance activities, particularly ground run-up engine testing. As a temporary measure, airport authorities have designated Runway 08 as the location for full power engine run-up procedures. However, this approach poses potential safety risks and environmental disturbances, especially related to noise and jet blast.

In comparison, several international airports in the United States—such as Chicago O'Hare (ORD), Milwaukee Mitchell (MKE), and Melbourne Orlando (MLB)—have implemented ground run-up enclosures (GRE). These facilities are aerodynamically designed and equipped with sound-dampening panels, capable of reducing aircraft engine noise by more than 50% while also mitigating jet blast effects during engine testing (Alaudin et al., 2023). Table 1 presents examples of GRE implementation at selected airports:

Table 1. Ground Run-Up Engine Facilities at U.S. Airports

NAMA BANDARA	GAMBAR GROUND RUN-UP ENCLOSURE
Bandara Internasioanal Chicago O'Hare (ORD)	
Sumber : https://oharenoise.org/sitemedia/documents/noise_management/ORD%20GRE%20FACT%20SHEET%202014.09.pdf	
Bandara Internasional Milwaukee Mitchel (MKE)	
Sumber : https://www.mitchellairport.com/airport-information/noise-management/ground-run-upenclosure	
Bandara Internasional Melbbourne Orlando (MLB)	
Sumber : https://www.iveysconstruction.com/project/orlando-melbourne-international-airport-ground-run-up-enclosure/	

Inspired by these best practices, the author proposes a simplified ground run-up enclosure design adapted from a previous study conducted at I Gusti Ngurah Rai International Airport. The proposed design integrates supporting technologies already in use in Indonesia, aiming not only to enhance aviation safety but also to create a new revenue stream for El Tari Airport.

Site mapping results indicate that the most suitable location for the ground run-up enclosure is on the southwest side of the airport, just before the runway end. This area is considered operationally strategic and poses minimal risk to other flight activities.

3.2. Design Results

The design phase produced key components for the proposed ground run-up enclosure facility at El Tari Airport, Kupang, along with a procedural flowchart for users (airlines) to submit usage requests to the apron movement control (AMC) authority. The design results are categorized into three main elements: deflector design, enclosure layout, and system flowchart.

3.2.1. Deflector Design

Unlike jet-engine aircraft that generate jet blast, the ATR72-600 produces propeller wash (or prop wash), a stream of air generated by its propellers. This airflow significantly affects aircraft performance, particularly during take-off and landing (M. Durgut, 2023). Prop wash contributes to airflow that helps maintain lift and aircraft control at very low forward speeds (Khan & Nahon, 2015).

Although official data on prop wash velocity is rarely published, general turboprop characteristics suggest airflow speeds behind the propeller range between 20–40 m/s (40–80 knots), with a safe distance of approximately ±3–10 meters from the propeller. Based on these specifications, the deflector was designed with dimensions of 50 meters in length, 8 meters in height, and 7 meters in width. The deflector surface is angled at 20° to effectively redirect the prop wash (Kusumo et al., 2021).

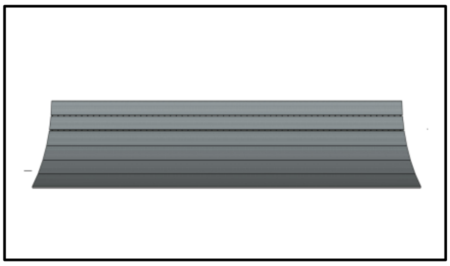

Figure 7. Front View of Blast Deflector

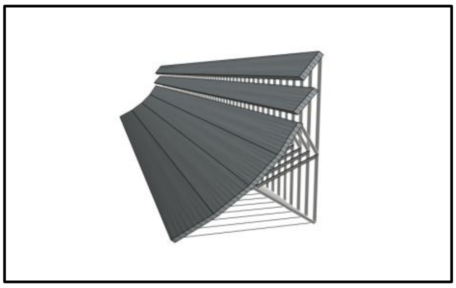

Figure 8. Side View of Blast Deflector

3.2.2. Ground Run-Up Enclosure Design

The ground run-up enclosure is designed to cover an area of 3,300 m², with dimensions of 60 meters in length and 55 meters in width. These specifications are tailored to meet the operational needs of El Tari Airport, particularly for ATR72-600 aircraft, which measure 27.17 meters in fuselage length and 27.05 meters in wingspan (Voskuijl et al., 2018). The enclosure provides sufficient space for aircraft maneuvering, including turning and repositioning.

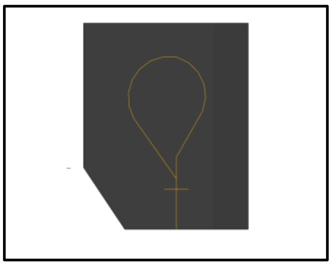

Figure 9. Top View of Ground Run-Up Enclosure Area

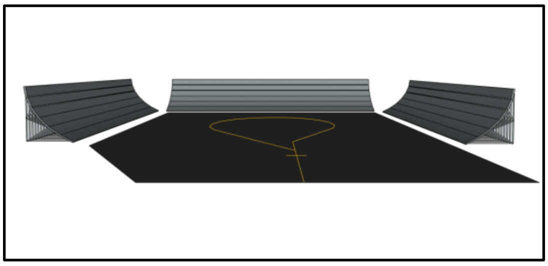

Figure 10. Front View of Ground Run-Up Enclosure

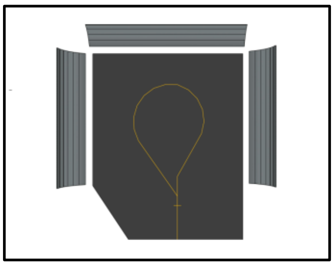

Figure 11. Top View of Ground Run-Up Enclosure

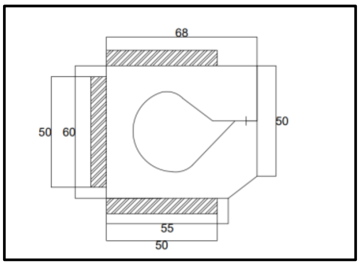

Figure 12. Layout of Ground Run-Up Enclosure

3.2.3. System Flowchart

The usage request system for the ground run-up enclosure is illustrated through a flowchart that outlines the communication process between the user (airline) and the apron movement control (AMC), which oversees all airside activities. The flowchart details the steps from submission to execution, with two possible outcomes:

1. **Rejected**: The request is denied due to operational or technical considerations by AMC.
2. **Approved**: The request is accepted, and the aircraft is repositioned from the apron via taxiway to the ground run-up enclosure for engine testing.

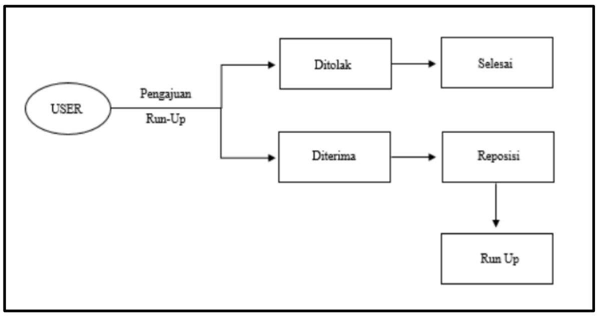

Figure 13. Flowchart of Ground Run-Up Enclosure Usage Request System

3.2.3. Development Results

The author designed a ground run-up enclosure at El Tari Airport, Kupang, to support aircraft maintenance facilities. The design was developed using the 3D SketchUp application due to its user-friendly interface and compatibility with standard computer specifications (Adly et al., 2021). The development process remains flexible and will be adjusted based on site conditions and approval from El Tari Airport authorities.

3.2.4. Implementation Results

The implementation stage involved applying the ground run-up enclosure design to the actual layout of El Tari Airport, Kupang. The placement of the design aimed to integrate the new facility into the airport's operational system both visually and functionally. The design visualization is presented from several perspectives: top view, front view, and rear view, as shown in Figures 8, 9, and 10.

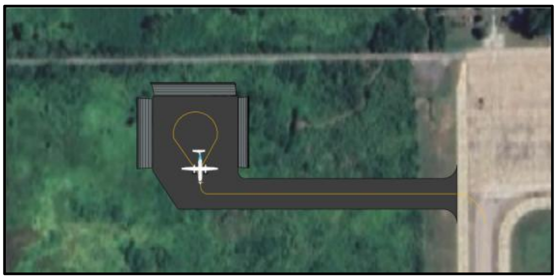

Figure 13. Top View Overall

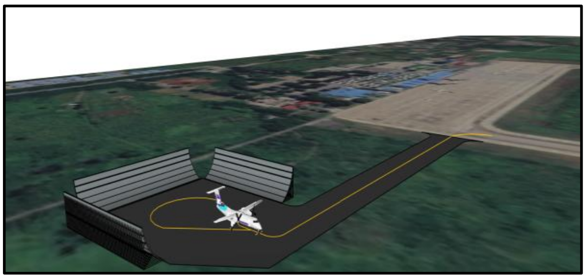

Figure 14. Front View Overall

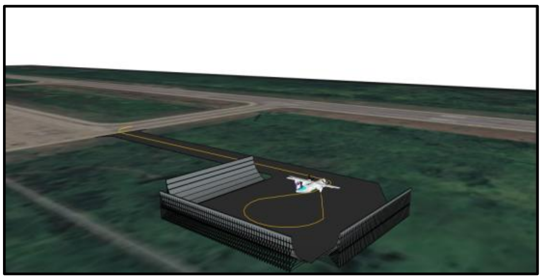

Figure 15. Back View Overall

3.2.5. Evaluation Results

the communication process between the user (airline)

3.2. Design Results

The evaluation stage represents the final step in the ADDIE development model. This phase was conducted to assess the extent to which the ground run-up enclosure design meets operational and safety requirements. Expert validation was carried out through interviews with three respondents from the Arpon Movement Control (AMC) unit at El Tari Airport, consisting of two supervisors and one operational staff member.

To ensure data validity, the researcher employed triangulation techniques. Source triangulation was conducted by comparing information from multiple respondents at different times, while methodological triangulation involved combining interviews and observations. These techniques were used to strengthen data credibility and minimize interpretive bias between researcher and respondent (Patton, 1987).

Triangulation also served to verify the consistency and accuracy of the collected information (Samsu, 2017).

Interviews were conducted with:

1. Roland Sirait – AMC Supervisor, El Tari Airport
2. Gilang Andi Saputro – AMC Supervisor, El Tari Airport
3. Fajar Sri Wiranadi – AMC Staff, El Tari Airport

The interview results indicated that the ground run-up enclosure design is considered effective in enhancing operational safety and supporting the relocation of engine run-up activities from the runway to a more controlled area. All three respondents agreed that the design offers a suitable solution. Roland Sirait emphasized that the facility helps reduce the risk of foreign object debris (FOD) and prevents disruptions to regular flight operations.

4. DISCUSSION

This study designed a Ground Run-Up Enclosure (GRE) using a Research and Development (R&D) approach to enhance operational safety and efficiency at El Tari Airport, Kupang, specifically for ATR72-600 aircraft. The discussion connects expert interview findings with the theoretical framework reviewed in Chapter 2.

4.1. Safety and Prop Wash Control

According to IAC Acoustics (2024), GREs are equipped with Jet Blast Deflectors to redirect engine airflow safely. Fajar Sri stated that the rear deflector design is crucial for protecting airside facilities from prop wash, supporting the theory that curved structures help reduce air pressure impact.

4.2. Technical Efficiency and Accessibility

Roland Sirait noted that the GRE's location near the apron facilitates aircraft repositioning by AMC personnel. Gilang Andi added that the entry and exit layout supports maintenance workflow efficiency.

4.3. Design Feasibility and Improvement

Experts agreed the current design is representative. However, Fajar Sri suggested adjusting the safety distance due to proximity to patrol routes and the VIP building. Gilang Andi recommended periodic testing of noise reduction and prop wash control, and emphasized the need for design flexibility to accommodate various aircraft types.

AUTHORS' CONTRIBUTIONS

The author was fully responsible for all stages of this research, including problem formulation, data collection, and the design of the Ground Run-Up Enclosure (GRE) at El Tari Airport, Kupang. The research methodology was developed using a Research and Development (R&D) approach, specifically the ADDIE model, and the needs analysis was conducted through field observations and interviews with Apron Movement Control (AMC) personnel.

The visual design of the GRE, including the blast deflector and operational layout, was independently created by the author using SketchUp. The author also developed evaluation instruments, conducted expert validation, and performed qualitative data analysis to assess the feasibility and effectiveness of the design.

All documentation, manuscript preparation, and final reporting were carried out independently by the author under academic supervision. The author ensured that the resulting design aligns with operational needs and complies with aviation safety standards.

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The author acknowledges that this research may still have limitations and welcomes constructive feedback for future improvement.

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