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Design of Standard Instrument Arrival (STAR) North Inbound at Kertajati International Airport

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Abstract

Kertajati International Airport is designed to serve as the main air gateway for West Java Province. However, there is currently no dedicated Standard Instrument Arrival (STAR) for flights arriving from the north. As a result, aircraft must follow indirect routes through several waypoints and different airspace sectors, leading to longer flight distances, increased workload for Air Traffic Controllers (ATCs), and reduced operational efficiency. This study aims to design an efficient and safe STAR North Inbound route for arrivals to Kertajati International Airport. The research adopts a Level 1 Research and Development (R&D) approach, consisting of literature review, data collection, flight procedure design based on ICAO Doc 8168 PANS-OPS, and design validation by certified Flight Procedure Designers. The results show that the proposed STAR North Inbound design reduces flight distance by 98.9 nautical miles compared to the current routing. Additionally, the new procedure minimizes airspace transitions and communication frequency changes, thereby reducing ATC workload and improving navigation service efficiency. From a safety perspective, the proposed design meets all obstacle clearance and protection area requirements in accordance with ICAO standards. In conclusion, the proposed STAR North Inbound route is deemed feasible for further review and development through inter-unit coordination, flight validation tests, and operational simulations prior to official implementation. The design supports safer, more effective, and more efficient air navigation services at Kertajati International Airport.

Keywords: Standard Instrument Arrival (STAR), North Inbound, Flight Efficiency, Flight Procedure Design, Kertajati International Airport

INTRODUCTION

Indonesia is a vast archipelagic country stretching from Sabang to Merauke, consisting of thousands of islands. To connect the nation from one region to another, efficient modes of transportation are essential to facilitate government activities and public mobility in areas such as the economy, trade, and other sectors. Among these, air transportation has become the most preferred mode by the public, as it prioritizes safety, speed, time efficiency, and comfort, while also effectively supporting the mobility of people and goods across Indonesia's geographically dispersed islands (Ahyudanari, 2021; Sufrianto et al., 2024). This is reflected in the increasing number of passengers, flight operations, and rapid advancements in aviation technology (Utama, 2021).

To support these developments, adequate aviation infrastructure and facilities must be provided to reach all regions of Indonesia, one of which is the construction of airports. One of the government's major initiatives in advancing the air transportation sector is the development of Kertajati International Airport, located in Majalengka Regency, which serves as the main gateway for West Java Province, replacing Husein Sastranegara Airport in Bandung (Nawir et al., 2022).

The AirNav Indonesia Kertajati Unit (Perum LPPNPI Unit Kertajati) is the entity responsible for managing airspace operations within Kertajati Airport's jurisdiction. This unit provides air navigation services within the Majalengka Control Zone (CTR), accommodating all types of traffic, including scheduled commercial flights, training aircraft, and overflying operations. Air traffic services are provided through the Kertajati Tower (TWR) under a combined service system, in which Aerodrome Control Tower and Approach Control Unit services are managed using the same radio frequency within a defined area. Vertically, Kertajati Tower's jurisdiction extends from the surface up to 10,000 feet. Beyond this altitude, Kertajati Tower must coordinate with adjacent units, especially Jakarta Terminal Maneuvering Area (TMA), when there is traffic leaving the Majalengka CTR (SOP, 2022).

The Jakarta TMA serves as one of the adjacent air traffic control units directly interacting with Kertajati Tower, particularly for aircraft operating above 10,000 feet. Given the limited vertical airspace under Kertajati Tower's control, most aircraft departing from or arriving at Kertajati Airport pass through airspace managed by Jakarta TMA, especially those operating under Instrument Flight Rules (IFR) above 10,000 feet (SOP, 2022). To ensure safe and efficient flight operations, all IFR traffic departing from and arriving at Kertajati Airport must follow Standard Instrument Departure (SID) and Standard Instrument Arrival (STAR) procedures that have been officially published

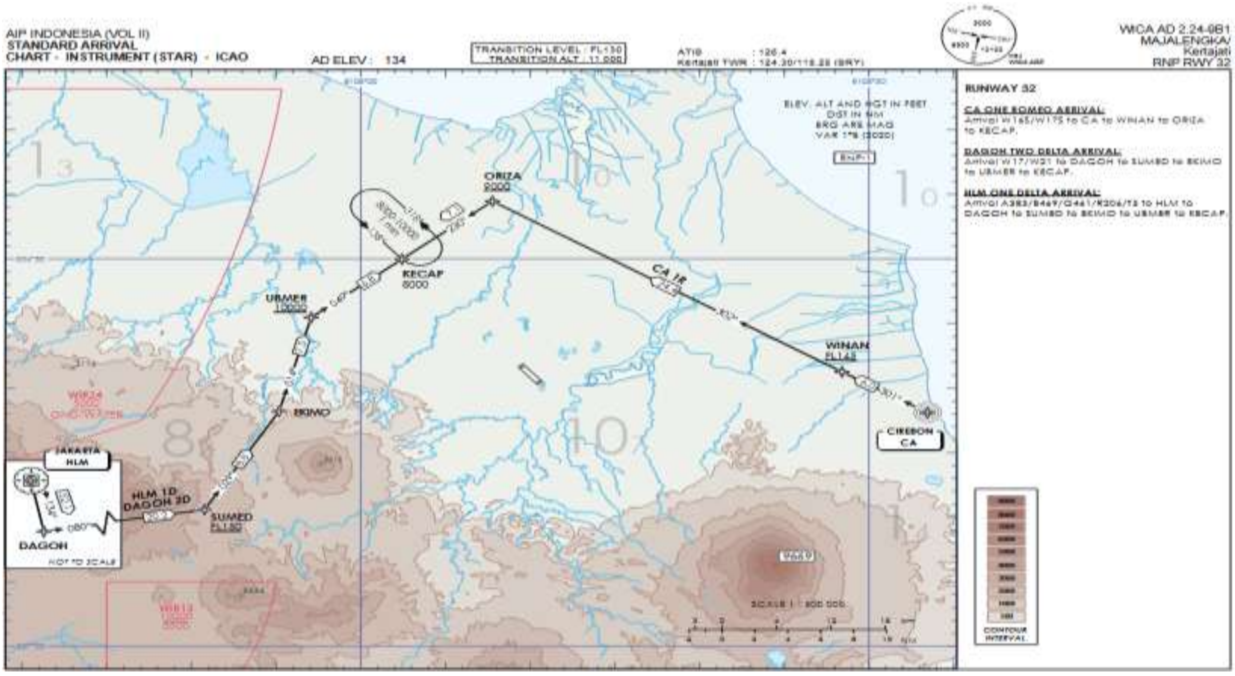

Figure 1 Standard instrument arrival chart RWY 14
Source : AIP Indonesia Vol II AIRAC AIP AMDT 165

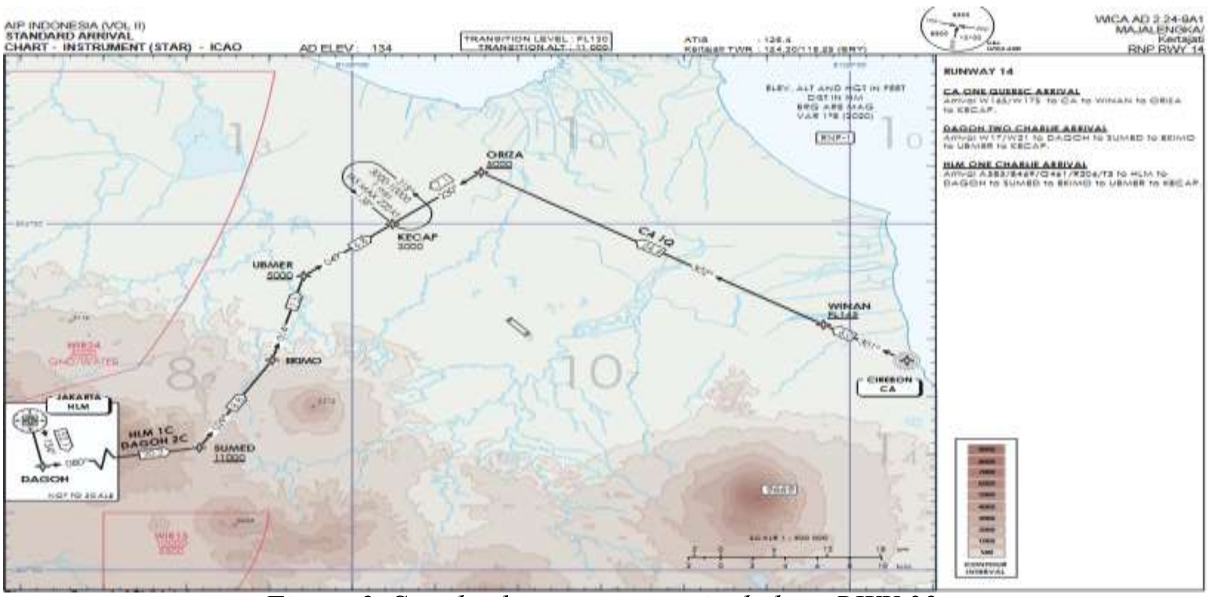

Figure 2. Standard instrument arrival chart RWY 32
Source : AIP Indonesia Vol II AIRAC AIP AMDT 165

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Every aircraft operating under Instrument Flight Rules (IFR) and inbound to Kertajati International Airport is initially guided by the Jakarta Terminal Maneuvering Area (TMA), as these aircraft typically operate at altitudes above 10,000 feet. The inbound flights follow Standard Instrument Arrival (STAR) routes that have been officially published, as illustrated in Figures 1 and 2. This airspace is managed by AirNav Indonesia through the Jakarta Air Traffic Service Center (JATSC) (Perum LPPNPI Cabang JATSC, 2025). Based on the current STAR charts, there are three published arrival routes to Kertajati, which can generally be divided into two primary directional flows: aircraft arriving from the west are directed toward the DAGOH waypoint, while those arriving from the east are guided toward the CA waypoint.

However, aircraft approaching from the north currently lack a dedicated STAR procedure. As a result, these aircraft are often rerouted along a longer and less efficient path passing sequentially through AMBOY, DKI, and HLM waypoints before joining one of the existing STARs toward Kertajati. This indirect routing not only increases flight distance and fuel consumption but also adds to the workload of air traffic controllers due to the need for additional coordination and vectoring. The typical traffic flow from the northern sector toward Kertajati International Airport following this pattern is illustrated in Figure 3.

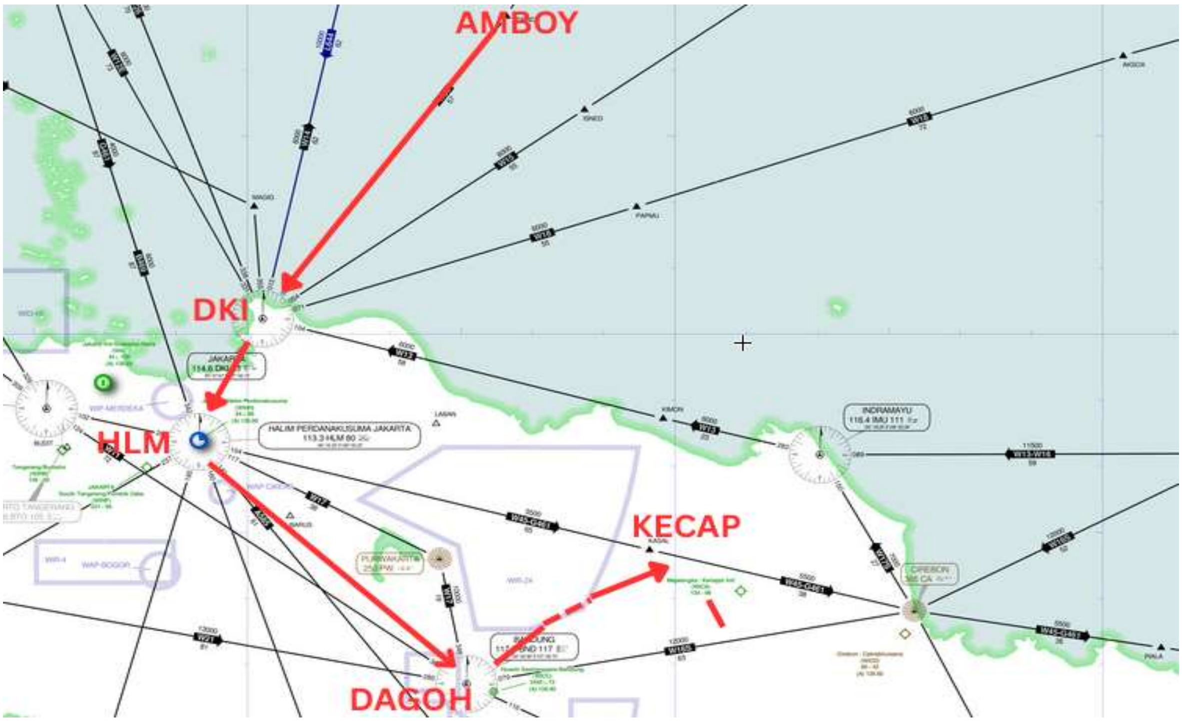

Figure 3. Illustration of Aircraft Traffic Approaching Kertajati International Airport from the Northern Sector

From the illustration shown in Figure 3, it can be observed that aircraft arriving from the north toward Kertajati International Airport are routed in such a way that they must first turn westward and then southward before proceeding to the KECAP waypoint. This routing pattern is considered inefficient, as it results in a longer flight path and increased fuel consumption. Furthermore, as depicted in Figures 4 and 5, aircraft following this route must transition through multiple airspace sectors, requiring additional coordination between different air traffic control units. This complexity highlights the need for a more direct and streamlined arrival procedure for aircraft approaching Kertajati from the northern direction.

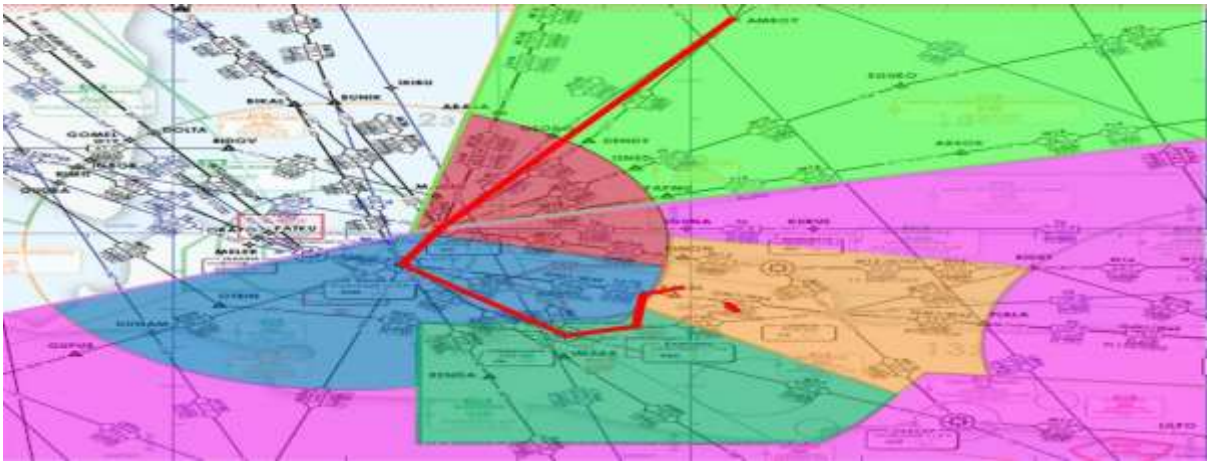

Figure 4. Airspace Structure of Jakarta and Its Surrounding Area (1)

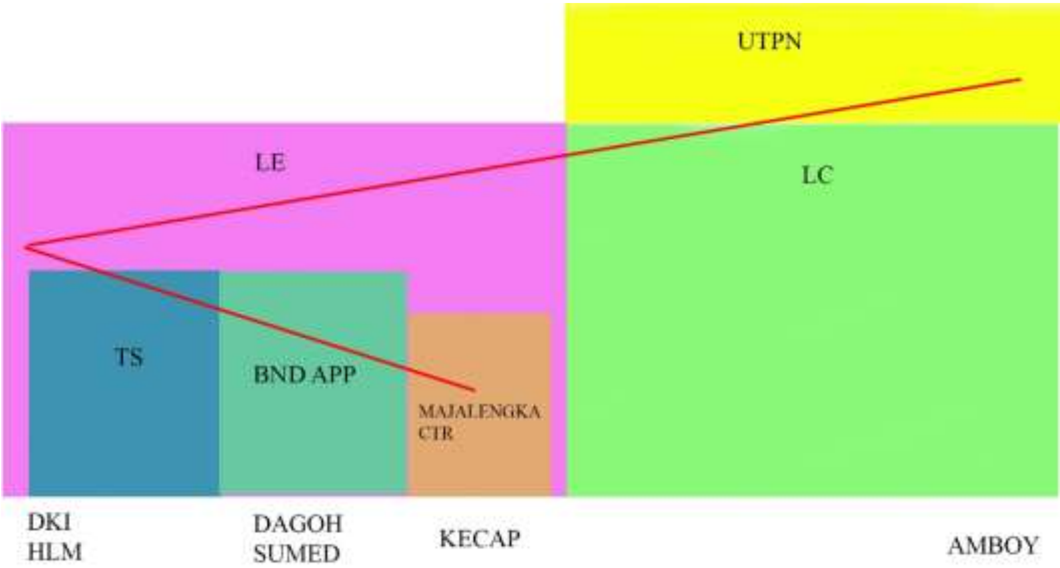

Figure 5. Illustration of Flight Path through Jakarta Airspace

Airspace Description :

- UTPN : Jakarta ACC Upper Tanjung Pandan
- LC : Jakarta Lower Center
- LE : Jakarta Lower East
- TS : Jakarta Approach Terminal East
- BND APP : Bandung Approach
- MAJALENGKA CTR (Kertajati TWR) : Majalengka Control Zone (Kertajati Tower)

From Figures 4 and 5, it can be observed both laterally and vertically that before entering the Majalengka airspace, every aircraft bound for Kertajati International Airport must pass through five different airspace sectors, namely: UTPN > LC > LE > TS > BND APP > Majalengka CTR. This sequence of airspace transitions requires pilots to communicate with multiple controllers within a relatively short period as they leave one sector and enter another. Such frequent communication handovers have the potential to increase workload for both pilots and Air Traffic Controllers (ATCs) (Brout et al., 2008).

Based on interviews conducted by the author with several ATC officers at AirNav Indonesia Jakarta Air Traffic Service Center (JATSC), it was found that the current STAR configuration for traffic arriving from the north is inefficient. Aircraft must first deviate westward and southward before reaching the waypoint KECAP to commence the Initial Approach Procedure (IAP). Ideally, in the provision of air navigation services, efficiency and effectiveness should also be prioritized alongside safety considerations. This inefficiency is evidenced by the frequent requests from pilots for direct routing to waypoints instead of following the extended STAR path, indicating a need for a more optimized arrival procedure for northern inbound traffic.

RESEARCH METHODS

This research employs the Research and Development (R&D) method, as the primary objective of the study is to develop a product in the form of a flight procedure design, specifically the Standard Instrument Arrival (STAR) North Inbound for Kertajati International Airport. According to Sugiyono (2020), a research method is a scientific way used to obtain data for a specific purpose and utility. The R&D approach is considered appropriate because this study not only seeks to understand a phenomenon but also aims to produce a practical, applicable solution that can be implemented by the air navigation service provider, AirNav Indonesia (Perum LPPNPI).

Referring to Aminarno Budi Pradana (2019) in Metode Penelitian Ilmiah, R&D is categorized into four levels of research intensity. This study applies R&D Level 1, which focuses on developing a conceptual or prototype design without progressing to the production or field-testing stage. The steps undertaken in this study follow the Level 1 research model, consisting of problem identification, literature review, design development, expert validation, and evaluation of design feasibility.

The research was conducted at AirNav Indonesia – Jakarta Air Traffic Service Center (JATSC), located at Building 611, Soekarno-Hatta International Airport, Tangerang, Banten. This location was chosen because JATSC has jurisdiction over the Jakarta Terminal Maneuvering Area (TMA), which directly interfaces with Majalengka Control Zone (CTR) managed by Kertajati Tower (TWR). The study was carried out over a five-month period, from September 2025 to January 2026, encompassing the stages of preparation, data collection, analysis, and final report writing.

Data collection techniques included interviews, field observations, and document studies. The interviews were conducted in an unstructured format with Air Traffic Controllers (ATCs) at JATSC to gather insights regarding the efficiency and challenges of existing STAR procedures. As stated by Pradana (2019), interviews are a direct data collection method involving interaction between the researcher and the source to obtain information. Field observations were conducted to better understand operational procedures, coordination between ATC units, and aircraft flow within the Jakarta TMA. In addition, a documentary study was performed using official aviation references such as ICAO Doc 8168 PANS-OPS Volume II, CASR 173, Air Traffic Service SOP (SOP, 2022), and internal technical documents from AirNav Indonesia JATSC (2025).

The data processing stage followed three main steps: data reduction, data presentation, and design validation. Data reduction was carried out by filtering and organizing the information relevant to STAR design, as suggested by Sugiyono (2020). Data were presented in the form of descriptive narratives, tables, and technical diagrams to support clarity in analysis. The validation stage aimed to ensure that the proposed design met the scientific, procedural, and safety standards required for aviation operations. As defined by Sugiyono (2020), design validation involves expert evaluation to assess the accuracy, applicability, and reliability of a proposed product. In this study, validation was conducted by two licensed Flight Procedure Designers (FPD) certified under CASR 173, along with operational ATC personnel from AirNav Indonesia.

The research flow followed the model of Level 1 Development Research proposed by Pradana (2019), consisting of several key stages. First, problem identification was performed through preliminary observation and gap analysis between the existing condition and the ideal condition (Kim & Ji, 2018). Second, literature study was conducted by reviewing theoretical foundations and procedural standards outlined in ICAO Doc 8168, CASR 173, and relevant prior studies concerning route optimization and flight efficiency (Singh & Sharma, 2015; Zhou, 2024). Third, the design stage involved collecting waypoint data, calculating segment distances and protection areas, and drafting the STAR procedure using AutoCAD 2023 and Microsoft Excel in accordance with PANS-OPS Volume II (ICAO, 2020). Fourth, design validation was conducted through expert review by certified flight procedure designers to ensure compliance with ICAO and national safety standards. Finally, evaluation was performed by comparing the new route's distance, number of airspace transitions, and overall impact on navigation service efficiency.

To ensure data validity and reliability, the study applied triangulation of sources and methods, combining the results of interviews, field observations, and document analyses. According to Sugiyono (2020), triangulation is a technique used to verify data credibility by cross-checking information obtained through different sources and collection methods. Furthermore, the design validation process by certified experts served as a technical credibility test, confirming that the proposed STAR North Inbound meets both safety and operational feasibility standards (Perum LPPNPI Cabang JATSC, 2025; ICAO, 2020).

RESULT AND DISCUSSION

This research was conducted at AirNav Indonesia Jakarta Air Traffic Service Center (JATSC), located in Building 611, Soekarno-Hatta International Airport, Tangerang, Banten. This unit is one of the regional branches responsible for providing air navigation services to aircraft operating within the Jakarta Flight Information Region (FIR) and the Jakarta Terminal Maneuvering Area (TMA). The airspace under JATSC's jurisdiction includes several sectors, namely Jakarta ACC Upper Tanjung Pandan (UTPN), Jakarta Lower Center (LC), Jakarta Lower East (LE), Jakarta TMA East (TE), Jakarta TMA South (TS), and Majalengka Control Zone (CTR), which is controlled by Kertajati Tower (TWR).

In addition, Kertajati International Airport (WICA), with an elevation of 134 feet and coordinates at 06°38'54" S and 108°09'15" E, serves as the primary object of this research. Based on airspace mapping, the Majalengka CTR has a vertical limit of up to 10,000 feet, while the airspace above it is controlled by the Jakarta TMA and relevant ACC sectors (SOP, 2022; Perum LPPNPI Cabang JATSC, 2025).

Presentation of Research Findings

1. Preliminary Study

The initial phase of this research was conducted through a preliminary study using a Gap Analysis approach, aiming to identify discrepancies between the existing conditions and the ideal conditions desired (Kim & Ji, 2018). The analysis revealed that there is currently no dedicated Standard Instrument Arrival (STAR) route for northbound traffic into Kertajati Airport.

As a result, IFR aircraft arriving from the north must be routed through several waypoints, namely AMBOY - DKI – HLM - KECAP, which increases flight distance and ATC workload (Brout et al., 2008). The ideal condition expected is the establishment of a dedicated North Inbound STAR that efficiently and safely connects the en-route phase to the Initial Approach Fix (IAF) (ICAO, 2020).

2.Needs Analysis (Need Assessment)

The researcher conducted unstructured interviews with ATC personnel at JATSC to obtain insights into the effectiveness of the current STAR procedures. The findings indicate that the existing STAR configuration is inefficient, as aircraft from the north must detour westward and southward before reaching KECAP, the designated IAF.

Most respondents stated that pilots frequently request direct routing to KECAP to reduce distance and flight time. However, such clearances are difficult to grant due to potential conflicts with arrival and departure routes from Soekarno-Hatta International Airport. Consequently, there is a clear need for a newly designed STAR that is more efficient and does not interfere with existing routes (Appendix 3; Perum LPPNPI Cabang JATSC, 2025).

Design Results

1. Waypoint Data Collection and Analysis

Waypoint data served as the primary foundation for the STAR design. The waypoints used include AMBOY, AKNER, PAPMU, POIN2, POIN1, and KECAP, with KECAP designated as the Initial Approach Fix (IAF). Additional waypoints, POIN1 and POIN2, were incorporated to optimize the transition from the en-route segment to the IAF. Calculations indicate that the total distance from AMBOY to KECAP via the proposed route is 145.1 Nautical Miles (NM) significantly shorter than the existing route of 244 NM. Thus, the new STAR design reduces flight distance by 98.9 NM, substantially improving fuel efficiency and flight time (Seymour et al., 2020).

2. Protection Area and Turn Parameters

In determining the protection area, the design follows the standards specified in ICAO Doc 8168 PANS-OPS Volume II. The protection area is divided into the Primary Area (PA) and Secondary Area (SA), each with half the value of the Area Semi-Width (ASW). The results show that the POIN1- POIN2 segment was adjusted from 1.75 NM to 1.25 NM, reflecting the distance relative to the Aerodrome Reference Point (ARP). Furthermore, turning points at waypoints PAPMU, POIN2, and POIN1 were computed using parameters such as aircraft speed, altitude, and track direction. The resulting turn radius and Turn Initiation Distance (TID) were found to be consistent with ICAO limitations, ensuring that the designed flight paths are safe and compliant for all aircraft categories (ICAO, 2020).

Design Validation

Validation was carried out through interviews with two licensed Flight Procedure Designers (FPD) certified under CASR 173. Based on their assessment, the following conclusions were drawn:

1. The data and methodology used conform to ICAO Doc 8168 standards.
2. The tools and software, such as Microsoft Excel and AutoCAD, meet the technical accuracy requirements for flight procedure design.
3. The protection area calculations comply with international aviation safety standards.
4. The proposed STAR North Inbound is deemed feasible for testing and implementation, pending a Flight Validation Test (FVT) and inter-unit coordination.

Both validators concluded that the design not only improves route efficiency but also maintains high safety standards (Perum LPPNPI Cabang JATSC, 2025).

Results Analysis and Discussion

Based on the collected data and validation outcomes, the proposed STAR North Inbound demonstrates significant benefits in both operational efficiency and flight safety. The 98.9 NM reduction in flight distance directly translates into fuel savings, lower carbon emissions, and improved ATC performance efficiency (Seymour et al., 2020; Singh & Sharma, 2015).

Additionally, the newly designed route traverses only three airspace sectors Jakarta Lower Center (LC), Jakarta Terminal East (TE), and Majalengka CTR (Kertajati TWR) in contrast to the five sectors involved in the current routing. This simplification reduces the frequency of handoffs and inter-sector coordination, thereby lowering the workload of controllers and enhancing situational awareness during air traffic operations (Brout et al., 2008).

From a safety perspective, Minimum Obstacle Clearance Altitude (MOCA) calculations confirm that all route segments maintain adequate terrain clearance, with the highest obstacle elevation being only 25 meters above contour level (Global Mapper Data). Thus, the new STAR meets all obstacle clearance criteria stipulated in ICAO Doc 8168.

Final Discussion

The proposed STAR North Inbound to Kertajati International Airport is considered feasible for implementation following Flight Validation Testing (FVT) conducted by the Directorate of Air Navigation. The adoption of this new route is expected to:

- Enhance operational efficiency and reduce flight time;
- Minimize Air Traffic Controller workload through simplified coordination between units;
- Satisfy the design quality and safety standards outlined in ICAO PANS-OPS and CASR 173;
- Support the optimization of air navigation services across the West Java Province region.

CONCLUSION

This study designed and evaluated a Standard Instrument Arrival (STAR) North Inbound procedure for Kertajati International Airport (WICA) to improve route efficiency and air traffic management. The current STAR configuration does not accommodate arrivals from the northern sector, forcing aircraft to fly longer, less efficient routes and increasing workload for both pilots and controllers. The proposed North Inbound STAR, connecting waypoints AMBOY - AKNER - PAPMU - POIN2 - POIN1 - KECAP, shortens the total flight distance from 244 NM to 145.1 NM, resulting in a reduction of 98.9 NM. This improvement enhances operational efficiency through fuel savings, shorter flight times, and reduced controller coordination. Design calculations comply with ICAO Doc 8168 PANS-OPS Volume II, covering protection area and obstacle clearance requirements. Validation by certified Flight Procedure Designers (FPDs) under CASR 173 confirmed the design's technical accuracy and regulatory compliance (Perum LPPNPI Cabang JATSC, 2025). The new route also simplifies airspace transitions, reducing communication frequency changes and improving situational awareness. Overall, the STAR North Inbound is technically feasible and operationally safe for further assessment through Flight Validation Testing (FVT). Its implementation will support safer, more efficient, and sustainable air navigation services in the West Java region.

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