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HELICOPTER PROCEDURE DESIGN FOR AIR TRAFFIC MOVEMENT IMPROVEMENT: A CASE OF KERTAJATI INTERNATIONAL AIRPORT

Diko Bagus Sugiarto[1], Togi Adnan Maruli Sinaga[2], Dedy Fachrudin[3], Rini Sadiatmi[4*], Endang Sugih Arti[5], Elfi Amir[6]
[1,2,4,5,6]Politeknik Penerbangan Indonesia Curug, [3]Balai Pendidikan dan Pelatihan Penerbangan Curug
* Correspondence e-mail: rini.sadiatmi@ppicurug.ac.id

Abstract
A review of Aeronautical Information Publication Indonesia Volume II indicates a critical infrastructure deficiency at Kertajati International Airport. The absence of a designated helipad presents a significant obstacle for air traffic controllers. This research proposed helicopter procedures designed for instrument flight rules to improve air traffic movement at Kertajati International Airport. A qualitative approach using interviews and document analysis was employed. The research identified a critical omission: the absence of designated helicopter take-off and landing locations. This lack of a framework hinders safe and efficient traffic management. The proposed procedure addresses this challenge by providing a structured approach for managing mixed rotary-wing and fixed-wing traffic, potentially reducing human error and delays, and fostering informed decision-making by air traffic controllers.

Keywords: *air traffic movement, aviation safety, helicopter procedures, instrument flight rules, kertajati airport*

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Introduction

A review of AIP Indonesia (Vol. II) Ad 0.4-1 International Aerodromes (Vol. 2, Issue 1) indicates a critical infrastructure deficiency at Kertajati International Airport (Midiawati et al., 2023; Prasetya & Sundoro, 2019). The absence of a designated helipad presents a significant obstacle for air traffic controllers (ATCs) (Bolton et al., 2019; Halbe et al., 2021; Hünemohr et al., 2022). Despite this limitation, flight data since 2018 reveals instances of military rotary-wing aircraft utilizing the airspace. This confluence of factors – the lack of a helipad and unforeseen rotary-wing traffic – demonstrably increases the workload for ATCs (see **figure 1**). Consequently, controllers are necessitated to extend their visual surveillance to the surrounding vicinity to maintain situational awareness and ensure the safe and efficient management of all air traffic, both fixed-wing and rotary-wing, including potential helicopter landings and take-offs, in the absence of a dedicated helipad (Aliaga, 2023; Lopez, 2021; Pietsch et al., 2021).

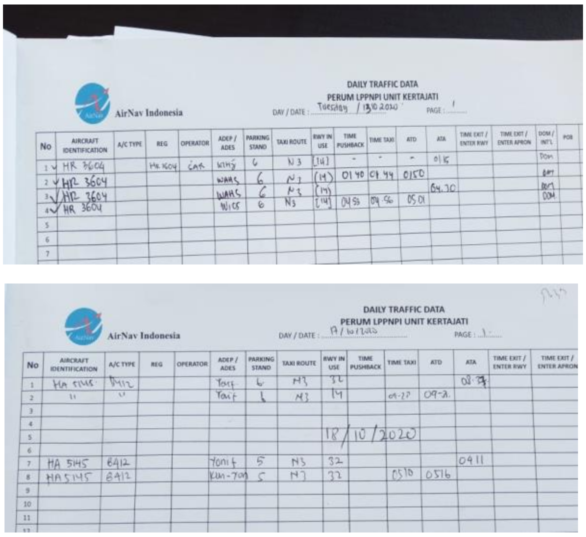

Figure 1. Daily Traffic Data in October

An examination of Civil Aviation Safety Regulations (CASR) Part 91 reveals a nuanced approach to the operational interaction between helicopters and fixed-wing aircraft. While specific provisions mandate helicopter pilots to actively avoid the established traffic flow of fixed-wing aircraft, other subsections appear to emphasize avoidance through recommendations rather than strict directives. In CASR Part 91, a framework of operational standards for helicopter pilots is established through a comprehensive approach that strikes a balance between the necessity of explicit mandates and the possibility of flexibility based on situational awareness (Midiawati et al., 2023; Volpe et al., 2011).

The field of helicopter procedure design finds its roots in military scholarship. McFadden's (1970) seminal work evaluated the impact of helicopter operations on air traffic control (ATC) during the 1970s. While his research concluded that helicopters would not pose significant challenges to ATC on a broad scale, he emphasized the need for specialized systems and procedures, particularly within terminal areas. Recognizing the limitations hindering the implementation of such procedures, Whitehouse and Brown (2003) subsequently proposed a modeling framework for helicopter procedure design. More recently, (Halbe et al., 2021) explored the concept of curved point-in-space procedures for helicopters within the context of Single European Sky air traffic management research. Building on this international body of knowledge, (Midiawati et al., 2023) presented a domestic contribution, proposing a helicopter entry point design specifically for users of Kendari Airport in Indonesia.

This research presented several critical inquiries concerning helicopter operations at Kertajati Airport. The primary concern is to determine if established flight procedures exist for helicopters in this airspace. Otherwise, a critical analysis is required to assess the urgency of implementing such procedures. Finally, the research must explore the methodology for designing an effective movement plan for helicopters operating within the confines of Kertajati Airport. This research aims to advance the field of helicopter flight operations by creating a new flight protocol that is customized for Kertajati Airport. This project aims to provide a defined set of rules that helicopter pilots operating in and near the aforementioned area can follow to ensure the predictability, efficiency, and safety of their actions.

Methods

This research adopted a qualitative approach, employing Creswell and Báez's framework to analyze text and images for patterns, themes, and meaning relevant to the research question. The following section details the data collection and analysis techniques used to illuminate the research subject. These techniques involved extracting data from transcribed interviews and analyzing pictures from informant-provided presentations (document studies) in **Table 1**, aiming to gather comprehensive participant data in **Table 2**. The research utilized a multi-method approach to gather comprehensive data. This involved examining existing helicopter flight procedures through document studies. Additionally, in-depth interviews were conducted with practitioners at Kertajati Airport, academics from universities, and experts from the air navigation industry. Open-ended questions and a conversational approach fostered detailed responses during the interviews. The snowball technique, informed by participant suggestions, further facilitated the exploration of emerging themes.

Table 1. Data Collection Techniques

Data collection techniques	Participants	Duration
Interviews	1. Academician 2. Expert from air navigation industry 3. Practician from Kertajati airport	Each informant was interviewed for a duration of 30 minutes to 1 hour.

Thematic analysis following Braun and Clarke (2006) guided a step-by-step process, employing an inductive approach for comprehensive exploration. Data was meticulously analysed and interpreted, resulting in categories reflecting the perspectives of diverse stakeholder groups (Table 2). Findings were then presented narratively, summarizing existing procedures and the challenges and opportunities associated with the missing procedures. This approach fostered a comprehensive understanding of stakeholder relationships and discrepancies regarding helicopter procedure design development.

Table 2. Data Categorization

Data Collection	Categorization
Interview FGD Document study	• Existing procedures • Helicopters procedures design

The study ensured ethical conduct throughout data collection involving human subjects. Participants were informed of the research purpose and its potential contribution to helicopter procedure development. Informed consent was obtained, and participant confidentiality and anonymity were guaranteed. Researchers respected participants' privacy and autonomy by allowing withdrawal from the study at any point.

The research adhered to ethical principles established by regulatory bodies. Transparency was maintained throughout, with clear reporting of methodology, findings, and limitations. Potential conflicts of interest were disclosed and mitigated. Interview and focus group conduct prioritized respectful interactions, avoiding intrusive questions, and remaining sensitive to participants' cultural and social contexts. Ethical review and permission processes were followed at the institutional level.

Results and Discussions

A review of Aeronautical Information Publication (AIP) Indonesia Volume II for Kertajati Airport reveals a critical data gap. The document lacks designation of authorized helicopter take-off and landing locations, as illustrated in **Figure 2**.

WICA AD 2.16 HELICOPTER LANDING AREA

Coordinates TLOF or THR of FATO Geoid undulation	NIL
TLOF and/or FATO elevation M/FT	NIL
TLOF and FATO area dimensions, surface, strength, marking	NIL
True BRG of FATO	NIL
Declared distance available	NIL
APP and FATO lighting	NIL
Remarks	NIL

Figure 2. Helicopter Landing Area

This omission poses a significant challenge for both helicopter pilots and air traffic controllers (ATCs), as the absence of a predefined operational framework for rotary-wing activity at the airport hinders safe and efficient traffic management. Informants provided conflicting reports regarding existing helicopter procedures. While some indicated the absence of any documented procedures, others suggested that Air Traffic Control (ATC) manages arrivals and departures visually using Visual Flight Rules (VFR). Additionally, some informants asserted that the existing circuit pattern for helicopter landings and take-offs complies with national regulations, requiring pilots to follow it while adhering to VFR procedures. One informant advocated for further research to develop formalized arrival and departure procedures encompassing VFR and Instrument Flight Rules (IFR) scenarios.

The design of a helicopter procedure for Kertajati International Airport necessitates the acquisition of several key data sets. The first comprises the aerodrome reference point (ARP) coordinates, retrieved from AIP Indonesia as presented in **Table 3**. Secondly, runway data for the airport is extracted from AIRAC AIP Indonesia, as shown in **Table 4**.

Table 3. Aerodrome Reference Point

X	Y
06º38'54"S	108º09'15"E

Table 4. Runway data of Kertajati Airport

RWY	DIRECTION	THR
14	139	06º38'13.16"S 108º09'24.59"E
32	319	06º39'27.91"S 108º10'27.45"E

Finally, obstacle data surrounding the airport will be compiled through a combination of field assessment and information obtained from AIRAC AIP Indonesia, as illustrated in **Figure 3**.

In Area 2					
OBST ID/ Designation	OBST type	OBST position	ELEV/HGT	Markings/Type, colour	Remarks
a	b	c	d	e	f
NIL	Antenna	APCH RWY 32 COOR : 064015.2S 1081126.8E	319.5ft	Markings/LGT	Distance 2333m and bearing 128º from THR RWY 32
NIL	Antenna	APCH RWY 32 COOR : 064039.0S 1081119.8E	322.5ft	Markings/LGT	Distance 2712.4m and bearing 144º from THR RWY 32
NIL	Antenna	APCH RWY 32 COOR : 064051.7S 1081121.1E	332.3ft	Markings/LGT	Distance 3057.3m and bearing 147º from THR RWY 32

In Area 3					
OBST ID/ Designation	OBST type	OBST position	ELEV/HGT	Markings/Type, colour	Remarks
a	b	c	d	e	f
NIL	NIL	NIL	NIL	NIL	NIL

Figure 3. Obstacle Data at Kertajati

This research recommended designing helicopter mobility procedures at Kertajati International Airport based on the discovered data gaps and the legal framework. Both Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) operations will be covered by these protocols. The first step is the VFR movement method, where the specified helicopter departure point is split into two reference points according to the direction of the desired flight. Point Alpha, situated at 6° 37'31.8" South latitude and 108° 10'49.3" East longitude, serves as the waypoint for northbound and eastbound departures from Kertajati Airport. Conversely, Point Bravo, located at 6° 39'59.2" South latitude and 108° 08'40.6" East longitude, is designated for southbound and westbound helicopter departures (Andreeva-Mori, 2024; Andreeva-Mori et al., 2023).

Furthermore, the departure procedure for helicopters operating at Kertajati International Airport involves a series of clearances and designated flight paths to ensure the safety and efficiency of air traffic. These procedures can be categorized as follows, (a) Helicopter Start-Up Clearance, Authorization to initiate engine start-up and prepare for taxiing is issued by Kertajati Tower, this clearance allows the helicopter pilot to activate the engines and conduct pre-departure checks in preparation for ground movement, (b) Helicopter Taxi Clearance, Following engine start-up and pre-departure checks, Kertajati Tower grants clearance for the helicopter to taxi from its designated parking location to the runway for take-off, this clearance ensures coordinated ground movement and avoids potential conflicts with other airport operations, (c) Helicopter Flight Path, Departure flight paths are differentiated based on the intended destination of the helicopter. Helicopters departing northbound or eastbound from Kertajati Airport proceed directly to Point Alpha, located at geographical coordinates 6° 37'31.8" S 108° 10'49.3" E. This designated waypoint serves as a navigational reference point for these flights, ensuring a coordinated transition from controlled airspace to uncontrolled airspace. (d) Southbound and Westbound Departures, Helicopters departing Kertajati Airport for southbound or westbound destinations are directed to proceed directly to Point Bravo, located at geographical coordinates 6° 39'59.2" S 108° 08'40.6" E. This designated waypoint facilitates a smooth transition to uncontrolled airspace for southbound and westbound helicopter traffic (refer to **Figure 4** for a visual representation of these departure points).

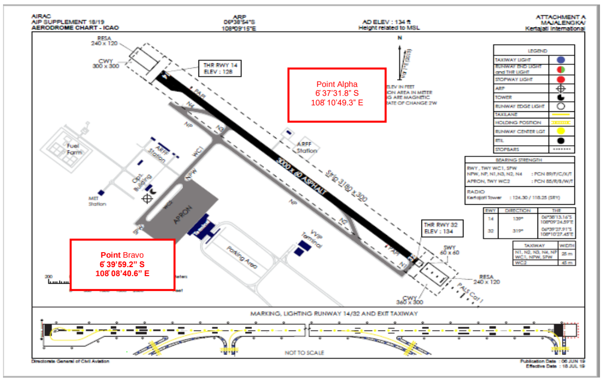

Figure 4. Lay out and reference

Helicopter arrivals at Kertajati International Airport adhere to a set of established procedures to ensure safety and efficiency. All incoming helicopters must comply with the designated circuit pattern for the airport. As pilot's approach either designated entry point (A: Empty Land or B: Kertasari Village Settlement), they are required to establish immediate contact with Kertajati *Air Traffic Control* (ATC). Landing clearance, holding instructions, or relevant traffic information will be provided by ATC based on prevailing conditions. In scenarios with congested airspace, arriving helicopters may be directed to hold over their assigned entry point until further instructions are issued.

The specific arrival procedures further diverge based on the runway currently in use. For arrivals when runway 14 is designated, helicopters approaching from the north and east will join downwind at 1000 ft after reaching entry point A. Conversely, helicopters arriving from the south and west will join right downwind at 1000 ft upon reaching entry point B. Both scenarios then require following the established circuit pattern for runway 14 (see **Figure 5**).

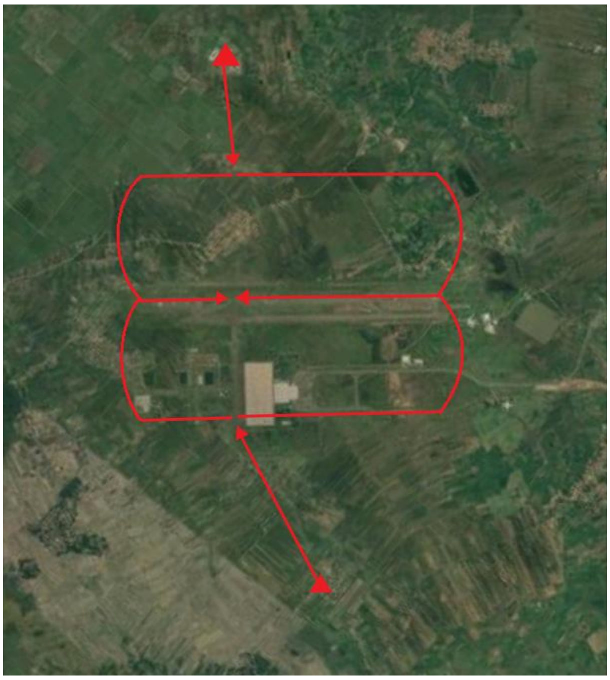

Figure 5. Point A and B from tower's

Similarly, when runway 32 is designated for arrivals, helicopters approaching from the north and east will join right downwind at 1000 ft after reaching entry point A. Helicopters arriving from the south and west will join downwind at 1000 ft upon reaching entry point B. Again, both scenarios necessitate following the established circuit pattern for runway 32. Following a successful landing, helicopters must adhere to ATC Kertajati's instructions for taxiing to the designated apron via the appropriate taxiways (Ayiei et al., 2020; de Voogt et al., 2020; Ramée et al., 2021).

Second, IFR movement procedure (RNP (GPS) 19) *Determining Obstacle Clearance Height (OCH) at Final Approach Fix (FAF)* in which safe aircraft operations during approaches rely heavily on the concept of Obstacle Clearance Height (OCH) at the Final Approach Fix (FAF) (de Voogt & St. Amour, 2021; Toratani & Hirabayashi, 2023). This crucial value is calculated using the formula, OCH = (MOC FAF + MOC Vegetation) * 3.281 + Nearest Obstacle.

Here, OCH represents the minimum height an aircraft must maintain above all obstacles during the approach. MOC FAF refers to the Minimum Obstacle Clearance mandated at the FAF, typically defined in meters (Ploetner et al., 2020; Romanović et al., 2024; Valerio et al., 2022). Similarly, MOC vegetation accounts for the minimum clearance required above any vegetation in the approach path, which is also expressed in meters. Finally, "Nearest Obstacle" represents the height of the closest obstacle along the approach trajectory, measured in feet (Chu et al., 2022; Unkelbach & Dautermann, 2022; Zhang, 2020). In this specific scenario, the calculation yields an initial OCH of 579.67ft (rounded to 580ft) after considering a MOC FAF of 40 meters, MOC Vegetation of 30 meters, and the nearest obstacle height of 350ft. However, due to the presence of an antenna obstacle, a revised OCA value of 580ft (177m) is established. This adjusted OCA ensures a safe clearance between the aircraft and all obstacles during the approach phase.

Final Approach Segment Procedures, Helicopters operating within the final approach segment at Kertajati International Airport will adhere to the established procedures designed for fixed-wing Category A aircraft. This alignment with Category A procedures ensures a standardized and safe approach profile for both aircraft types within the shared airspace.

Intermediate Segment Procedures and Protection Area Turning at IF, the intermediate segment of an instrument flight procedure extends from the Initial Approach Fix (IF) to the Final Approach Fix (FAF) (Halbe et al., 2021; Mehling et al., 2022). During this segment, aircraft follow the same procedures as fixed-wing Category A aircraft, maintaining a Minimum Obstacle Clearance Altitude (MOCA) of 900 feet.

Protection Area Turning at IF, turning at the IF requires careful consideration of various factors to ensure safe manoeuvring and obstacle clearance. The following steps outline the calculation of the protection area for turning at the IF, Given, Altitude = 2000 ft; Conversion Factor: 1.0567; Indicated Airspeed (IAS): 120 kts; Bank Angle (Z): 25 degrees; True Airspeed (TAS: V): 126.809 kts; and Change in Degrees: 90 degrees. Calculate, Turn Radius (R): R = (3431 x Tan25) / (π x TAS) = 4 degrees.

Turn Radius in Nautical Miles (r): r = TAS/(20 x π x R) = 0.51 Nm, Width of Protection Area (E): E = 0.32 Nm. Calculate Protection Area Dimensions: Short Leg (S): S = r*tan (change degrees/2) = 0.51 Nm, Centre Leg (c): c = E / 2 = 0.16 Nm. Determine Earliest and Latest Turn Points: Earliest Turn: ATT = 0.8 Nm, Latest Turn: ATT+c = 1.06 Nm.

Verify Obstacle Clearance, The computed protection area dimensions showed that there were no impediments in the region that was assigned. Designing a safe turning maneuver at the IF is based on the protection area turning parameters that are generated from this computation. The proposed turn's viability is confirmed by the lack of obstructions inside the protected area.

Determining Minimum Obstruction Clearance Altitude (MOCA) in the Initial Approach Segment (IAS), the Initial Approach Segment (IAS) is a crucial phase within the approach procedure where aircraft descend towards the runway while maintaining a safe distance from obstacles (Halbe et al., 2021; Mehling et al., 2022). To ensure this safety, the concept of Minimum Obstruction Clearance Altitude (MOCA) plays a vital role. MOCA defines the lowest permissible altitude for aircraft within the IAS, guaranteeing adequate clearance above all obstacles in the approach path (Ernst et al., 2021; Pant & Lee, 2020).

The calculation of MOCA utilizes the following formula, MOCA = (MOC + Highest Obstacle + Vegetation) * 3.281. Where MOCA: Minimum Obstruction Clearance Altitude (in feet). MOC, Minimum Obstacle Clearance (in meters) Highest Obstacle: Height of the highest obstacle within the IAS (in meters). Vegetation, height of the tallest vegetation in the IAS (in meters). Where **3.281:** Conversion factor from meters to feet.

In this specific scenario, the IAS extends from the Initial Approach Fix (IAF) to the Intermediate Fix (IF), covering a distance of 13.9 nautical miles. The MOC is 300 meters, while the highest obstacle and vegetation height are 10 meters and 30 meters, respectively. Applying the formula, the initial MOCA calculation yields a value of 1115.54 feet. This value is adjusted to 1200 feet following standard rounding practices, establishing the final MOCA for the IAS. This ensures that all aircraft within the IAS maintain a minimum clearance of 1200 feet above any obstacles in the approach path, guaranteeing safety during descent.

Missed Approach Procedure, The Missed Approach Procedure (MAP) serves as a critical safeguard in aviation, guiding pilots through a defined sequence of actions in the event of an unsuccessful landing attempt. This procedure is divided into three distinct phases: Initial, Intermediate, and Final.

Initial Phase, where we establishing the Climb, *it is* the Initial Phase commences at the Missed Approach Point (MAPt) and culminates at the Start of Climb (SOC). During this phase, the aircraft initiates its ascent away from the runway and prepares for further manoeuvres. The SOC calculation is determined using the following formula, SOC = ATT + d + x, where SOC: Start of Climb (in nautical miles); ATT: Missed Approach Time (in nautical miles); d: Distance travelled during initial climb (in nautical miles), x: Distance travelled during turn (in nautical miles). In this scenario, the values are as follows:

ATT : 0.24 Nm
IAS : 90 kts
Conversion Factor (alt 500ft): 1.0334
TAS : 93.006 kts
D : 3/3600 x (TAS+10 kts) = 0.077505 Nm
X : 5/3600 x TAS = 0.129175 Nm

Substituting these values into the formula, obtain, SOC = 0.20668 Nm.

Intermediate Phase, Turning towards the Intermediate Fix (IF). The Intermediate Phase begins at the SOC and involves a left turn towards the IF (Mehling et al., 2022; Unkelbach & Dautermann, 2022). The calculation for this turn is as follows. *TURN after missed approach*, where:

IAS : 120 Kts
Conversion Factor (alt 1000ft): 1.0411
Bank Angle : 15 deg
TAS : 124.93 kts
R: (3431 x Tan15) / (π xTAS) = 2.34 deg
r : TAS/20 πR = 0.85 Nm
Wind in 30 kts: 15.43333 m/s
E90 : 1389 m = 0.75 Nm.

Calculating the final distance, the square root of (r^2+E^2): 1.132726 Nm; r+E: 1.60 Nm; r+2E: 2.35 Nm.

Final Phase, heading towards the Initial Approach Fix (IAF) and Climbing. The final phase of the missed approach procedure involves turning towards the IAF and climbing to an altitude of 2000ft. This phase prepares the aircraft for either another approach attempt or holding. The specific altitude and approach procedures will depend on the prevailing conditions and air traffic control instructions.

Holding procedures are an essential aspect of air traffic management, particularly when aircraft need to maintain a position in a specific airspace while awaiting further instructions (Halbe et al., 2021; Midiawati et al., 2023). At Kertajati International Airport, holding is typically executed either above the Initial Approach Fix (IAF) or along a bearing of 000°/11.7Nm relative to the "KJT" VOR (Very High Frequency Omnirange) station. The holding template employed is derived from the Terminal Traffic Management (TTT) documentation, specifying an altitude of 2000ft and an airspeed of 120 knots (IAS). The design of the helicopter procedures adhered to the established guidelines outlined in the International Civil Aviation Organization (ICAO) Doc 8168, which governs aircraft operations (see **figure 6 and 7**).

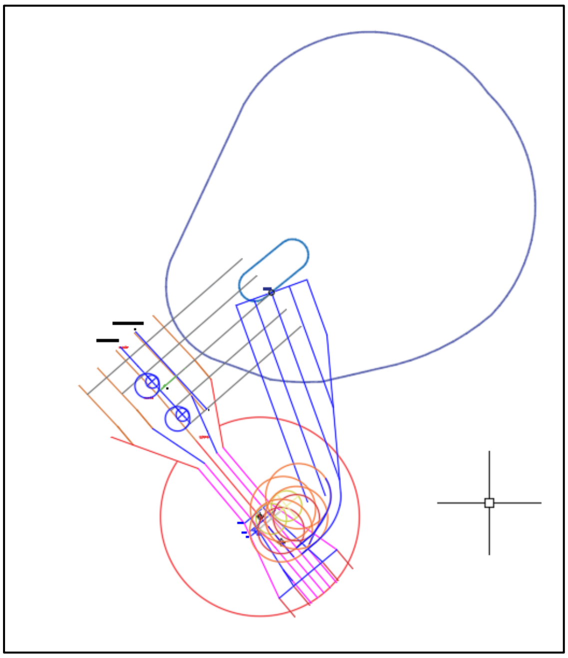

Figure 6. Design of Helicopter Procedure

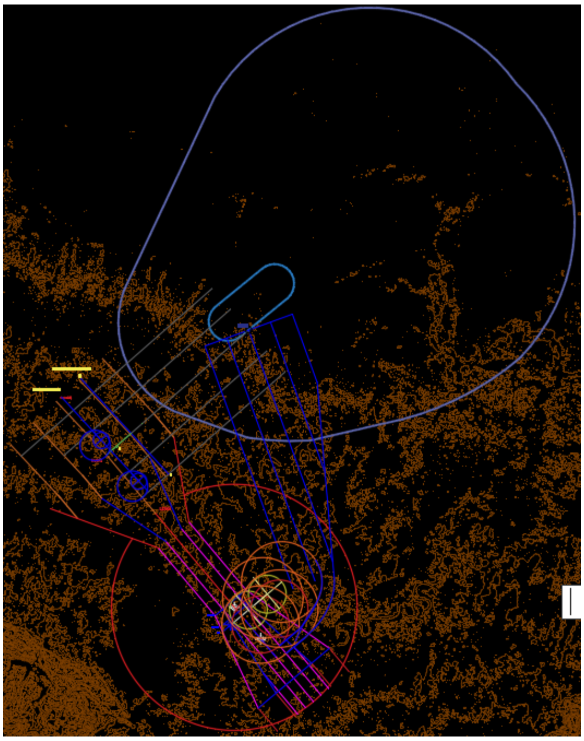

Figure 7. Design of Helicopter Procedure IFR with Contour

To ensure the validity and effectiveness of the designed procedures, this study employed a multi-informant validation process. Three key stakeholders were consulted: an expert on Procedures for Air Navigation Services - Operations (PANS-OPS), an academic researcher familiar with relevant aviation principles, and a practitioner with first-hand experience at Kertajati International Airport. This diverse group of informants provided valuable feedback, ultimately validating the design of the helicopter procedures. Furthermore, they recommended field-testing the procedures at Kertajati International Airport to assess their practicality and effectiveness in a real-world operational environment.

Conclusion

The proposed helicopter procedure for Kertajati International Airport addresses the challenges of managing mixed rotary-wing and fixed-wing traffic efficiently and safely. By implementing this procedure, air traffic controllers can effectively mitigate the risk of spontaneous and hasty decision-making under demanding conditions. This structured approach will enhance their ability to prioritize and manage air traffic while ensuring the safety of all aircraft. The implementation of this helicopter procedure will yield significant benefits for Kertajati International Airport. Firstly, it will enhance the safety of air traffic operations by reducing the likelihood of human error and miscommunication. Secondly, it will improve air traffic management efficiency, reducing delays and improving airspace utilization. Thirdly, it will contribute to air traffic controllers' overall professionalism and expertise, fostering a culture of structured and informed decision-making.

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