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Holding Point and Holding Pattern Feasibility Test for Training and Initial Approach Procedure

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A B S T R A C T

Holding pattern is an aircraft maneuver to remain in the air within a certain period to delay movement. This research aims to ascertain whether the creation of certain holding points used specificially for holding patterns exercises. This research uses the Research & Development (RnD) method which involves the process of planning, technical design, and feasibility test using Cessna 172Sp aircrafts. The results showed that the holding point could be carried out at the coordinates of the holding point coordinates 8°20'59"S 114°08'48.8"E which was then named point "MEYDA". The feasibility test results show that two holding patterns can be used, namely Model 1 (inbound 150° and outbound 330°) and Model 2 (inbound 080° and outbound 260°).

INTRODUCTION

Holding pattern is an aircraft maneuver to remain in the air in a certain area for a certain period to delay movement and wait for further instructions from Air Traffic Control (ATC). This procedure is performed when the aircraft cannot land or continue its journey as planned for various reasons, such as air traffic congestion, bad weather, or technical problems at the destination airport. (Artiouchine et al., 2008). Holding patterns are carried out at designated locations in an area based on ground or satellite references. (Tri Saputra & Muh Ibrahim, 2023).

Holding patterns are also used as a way of performing traffic management by organizing sequencing in the aircraft landing process. (Ma et al., 2024; Ng et al., 2021). The use of holding pattern is also one of the solutions to overcome air traffic flow, especially in the approach to be used in runway management (Ma et al., 2024; Ng et al., 2021). (Ma et al., 2024). The approach and landing process is the most dangerous phase in flight, so ensuring a good landing with the right pattern is the solution. (Ben Messaoud, 2021).

Conventional holding patterns are classified by height according to their requirements. These classifications correspond to differences in height that affect holding speed and duration (listed in Table 1). (Artiouchine et al., 2008). But in general, the holding pattern is an oval-shaped 180° turn at the end of each outbound leg and inbound leg, the aircraft turns with a bank angle of 25° to 30° or a rate of turn of 3° per second (ICAO Doc 8168). In the entry holding pattern procedure, there are 3 types, namely direct entry, parallel entry, and teardrop entry. All holding patterns are carried out under the direction and supervision of ATC who provide instructions regarding the holding fix point, holding altitude, holding time length, and holding exit instructions. Conventional holding points use references from VOR/DME to be the point/location of its holding point.

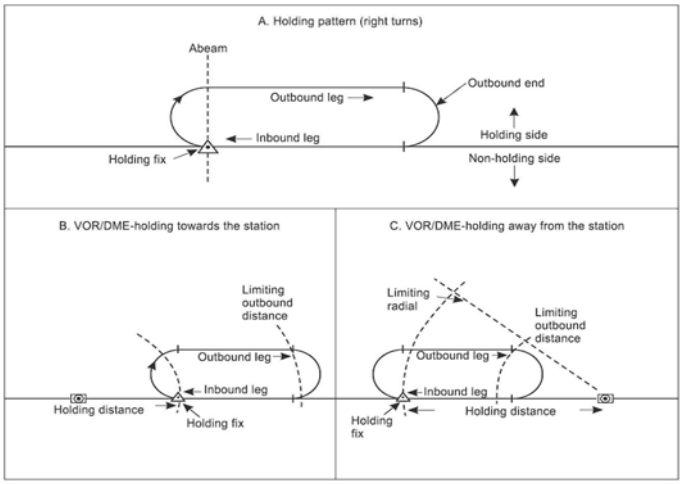

Figure 1 Holding Pattern Shape (Source: ICAO Doc 8168)

The determination of the holding area depends on the basic holding area and entry area. The basic holding area is the airspace required for the aircraft to hold at a certain altitude. (Artiouchine et al., 2008). Consideration factors for

determining the basic holding area are aircraft speed, wind effects, timing errors, and geographical characteristics at the fixed holding point. Meanwhile, the definition of Entry area is the airspace provided for the aircraft to perform the entry procedure into the holding pattern (Samà et al., 2017). This holding entry procedure is how the aircraft transitions from its flight path into the holding point. In determining this position, factors considered are the type of entry procedure and wind and speed considerations (Bennell et al., 2017).

Holding area determination also requires consideration of the buffer area to determine the minimum holding level. The buffer area is an additional area that extends 9.3 km (5.0 NM) beyond the holding area boundary. This area is added to provide additional assurance for the safety of aircraft that are in a holding pattern at a certain altitude. (Ma et al., 2024; Ng et al., 2017).

Holding patterns are also required for flight training in VFR and IFR flights. (Lieder et al., 2015). The activity occurs in the approach training phase by using a holding mechanism at a predetermined point (holding point). In the Instrument rating flight phase, the holding point is used as a reference for holding at the beginning of the instrument approach procedure. (Ikli et al., 2021; Ma et al., 2024).

The instrument rating exercise carried out by API Banyuwangi flight participants is currently at Lombok Praya International Airport, which allows them to make an approach preceded by holding at a predetermined point before finally carrying out the instrument approach procedure. The implementation of instrument rating flight training including the landing process with instruments cannot be carried out at Banyuwangi Airport, because Banyuwangi Airport is not equipped with one of the navigation aids either NDB or VOR.

Holding and initial approach procedure training can be conducted at Banyuwangi Airport, although Banyuwangi Airport does not have conventional equipment such as VOR or DME. Instrument approaches can be done using satellite-based references as recorded in aeronautical information publications published by Jeppesen. The aircraft belonging to the Indonesian Aviator Academy Banyuwangi has also been equipped with a Garmin 1000 which allows the user (pilot) to create a specific satellite-based reference point (temporary) to be used as a reference both for holding points and for other flight references.

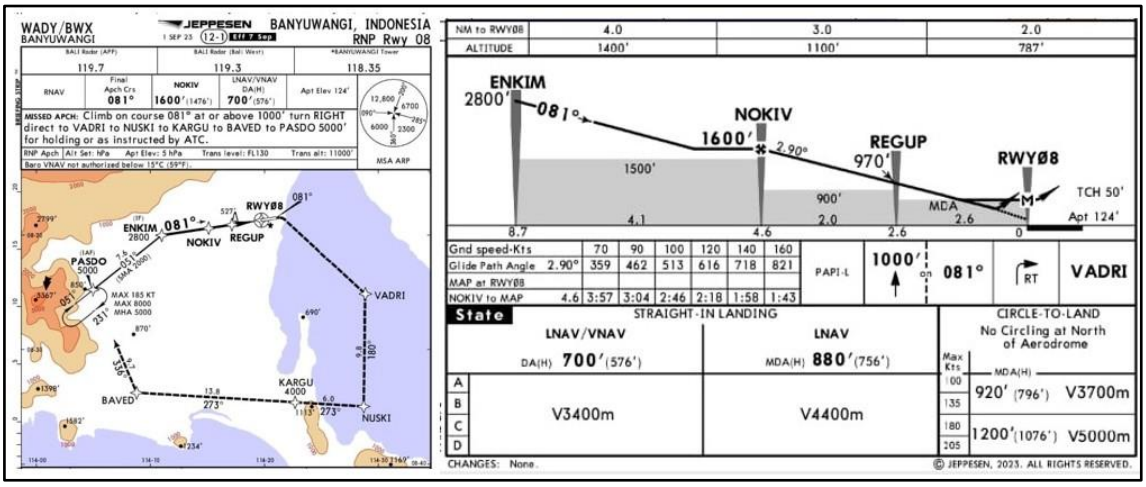

Figure 2. Banyuwangi AIP published by Jappesen

This research aims to ascertain whether the creation of certain holding points used for holding patterns for the purpose of holding exercises or aerial approach procedures can be carried out in the Banyuwangi airspace area. Based on these facts, several research questions were asked to limit the topic and discussion in this research, namely:
RQ 1. Which areas/points are suitable for holding?
RQ 2. How feasible is the site as a holding point for flight training?

THEORETICAL REVIEW

A holding pattern is an aircraft maneuver to remain in the air in a certain area for a certain period to delay movement and wait for further instructions from Air Traffic Control (ATC). This procedure is performed when the aircraft cannot land or continue its journey as planned for various reasons, such as air traffic congestion, bad weather, or technical problems at the destination airport (Artiouchine et al., 2008). Holding patterns are performed at designated locations in an area based on ground or satellite references (Tri Saputra & Muh Ibrahim, 2023).

During both entry and holding phases, pilots manually controlling the aircraft are expected to maintain an average bank angle of at least 25˚ or a turn rate of 3˚ per second, whichever results in a lesser bank angle. The inbound leg is flown along the designated radial or bearing towards the holding fix, while the outbound leg is adjusted for wind correction to facilitate a smooth turn back onto the inbound track. The duration of the outbound leg is calibrated to achieve the required inbound leg timing. Standard inbound leg timing is one minute at or below 14,000 feet and one and a half minutes when above 14,000 feet. When ATC clearance includes a specified departure time from the holding fix, pilots must adjust their holding pattern, staying within the established limits, to ensure exit from the fix as close as possible to the assigned time.

Parallel entry (Sector 1) is utilized when the aircraft's approach is approximately 110° to 180° offset from the inbound track. Upon crossing the holding fix, the aircraft proceeds outbound on a parallel course opposite the inbound track for one minute before executing a 180° turn to intercept the inbound leg. Teardrop entry (Sector 2) is applied when the aircraft approaches the holding fix with an offset of approximately 70° to 110° from the inbound track. After passing the fix, the aircraft turns 30° off the outbound track in the direction of the hold for one minute, followed by a turn to intercept the inbound track. Direct entry (Sector 3) is used when the aircraft's approach lies within 70° of the inbound track. The aircraft passes directly over the holding fix and immediately turns in the direction of the hold to establish on the outbound leg, eventually intercepting the inbound track (ICAO, 2018).

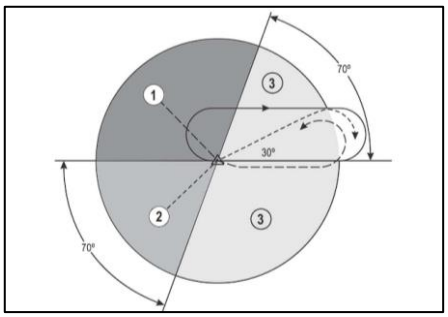

Figure 3. Entry Sector (Source: ICAO Doc 8168)

METHODOLOGY

This research used the Research & Development (RnD) method which involves the process of planning, technical design, and feasibility testing. (Chen & Chang, 2019; Vivekanantharasa, 2022). The stages carried out in this research are:

1. Determine the coordinates of the tile area and make observations for visual reference at that point.
2. Make sure the coordinates are in a suitable location to perform a holding maneuver with a minimum distance of 1 minute outbound and 1-minute inbound.
3. Design the inbound and outbound track direction of the pattern
4. Perform a holding trial on the coordinates as a reference waypoint
5. Ensure that the holding pattern with the 1-minute out procedure is still within the training area, and ensure visual reference at the bang of turn.
6. If the holding pattern is sufficient, exercise entry holding by trying to use the 3 entry possibilities available, namely teardrop, parallel (procedure turn), and direct.

In the process of implementing the holding point and holding pattern feasibility test activities using the Cessna 172Sp aircraft owned by API Banyuwangi which has been equipped with Garmin 1000, so that flight data can be retrieved and processed after the flight. Flight data reading uses data recorded in Garmin 1000 which is converted into KML files with GarminFlightLog software.

The implementation of data collection and testing of holding points and holding patterns is carried out at least 3 times, with a minimum of 3 flights. Holding point and pattern testing flights are carried out in conjunction with flight training practices carried out by flight students.

RESEACH RESULTS

This Holding Point created is a holding point specifically designed for flight training following the holding procedure in ICAO doc 8168 and given the name of the point is "MEYDA". To develop an effective holding pattern, it requires clear and structured steps in its determination so that the feasibility of this holding pattern can be analyzed later. 3 main steps are the basis for developing this holding pattern, namely:

1. Planning

a. Holding point position

All the plans we make are based on the holding procedures specified in ICAO doc 8168. To determine the position of the holding pattern itself is located at coordinates 8°20'59" South latitude and 114°08'48.8" East longitude, precisely in the Genteng area. Genteng area is also one of the 6 flight training areas in Banyuwang Airport. The Genteng area was chosen as the aircraft maneuver holding location because it has several strategic advantages. Geographically, this area provides a large and safe airspace for flight training, allowing aircraft to maneuver safely without disturbing commercial flight paths and other training flights. In addition, this location is within an ideal distance from Banyuwangi Airport as the main location for flight training, thus facilitating coordination between training aircraft and air traffic controllers (ATC). The topographical advantages of the Genteng area also support the implementation of holding pattern training which has considerable obstacles due to wind conditions that test students' skills around the airspace. Therefore, special mapping is required in the development of this holding point.

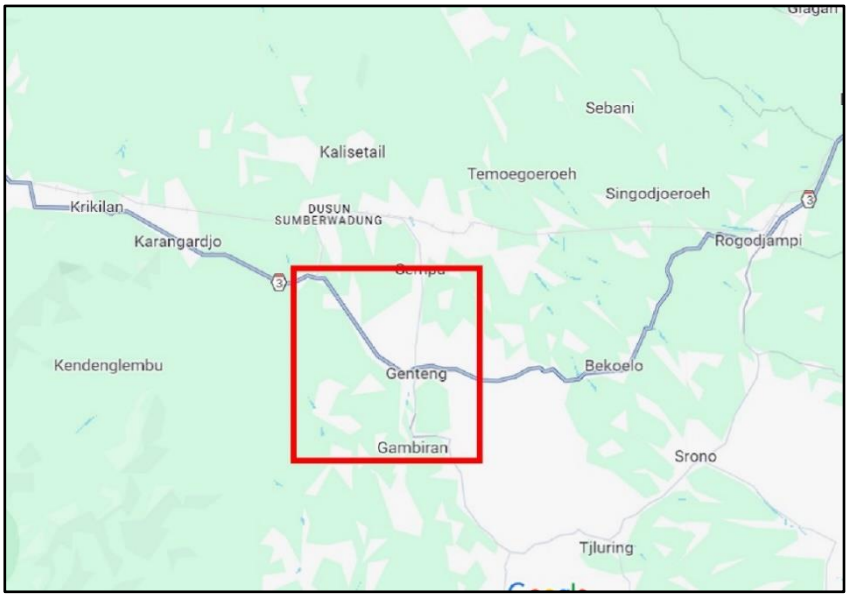

Figure 4. Determination of holding point locations.

b. Holding level

Referring to the holding procedure by ICAO doc 8168, the minimum holding level is 300m or 984 feet above the obstacle location. After analysis, we determine the suitable altitude for holding in the area at 3000 feet to adjust the landing approach at the next checkpoint (ENKIM) which is at an altitude of 2800 feet. So from our analysis, it can be concluded that the altitude of 3000 feet is the ideal altitude for holding because of its position far beyond the obstacle limit and the ideal altitude for the training aircraft to maneuver followed by approach landing.

c. Holding Pattern Duration, Speed, and Distance

The holding altitude that has been determined, can be followed by determining the duration, speed, and distance of this holding. The altitude of 3000 feet when classified, the data is obtained in the category of duration for 1 minute of holding. The most appropriate speed at this altitude is 100 Kt (NM/H). Therefore, from this data, the distance traveled during inbound and outbound holding can be obtained by calculating the formula $S = v \times t$ and the following calculation is obtained:

$$S = v \times t$$

$$S = 100 \times \frac{1}{60} \ (1\ minute)$$

$$S = 1{,}7\ NM$$

2.3 HOLDING

2.3.1 Still air condition

After entering the holding pattern, on the second and subsequent arrivals over the fix, the aircraft turns to fly an outbound track to position the aircraft for the turn onto the inbound track. It continues outbound:

a) where timing is specified:

1) for one minute if at or below 4 250 m (14 000 ft); or

2) for one and one-half minutes if above 4 250 m (14 000 ft); or

Figure 5. Holding duration (Source: ICAO doc 8168)

Table II-6-2-2. Holding speeds — Category H

Maximum speed up to 1 830 m (6 000 ft)	185 km/h (100 kt)
Maximum speed above 1 830 m (6 000 ft)	315 km/h (170 kt)
Note.— Minimum obstacle clearance (MOC) in secondary area for helicopter holding procedures is linear from zero to full MOC.	

Figure 6. Holding speed (Source: ICAO doc 8168)

d. Buffer area

To ensure the safety of holding maneuvers, a buffer area is needed to provide additional space for the aircraft so as to reduce the risk of obstacle hazards around. Based on ICAO doc 8168, holding patterns below 6000 feet require a buffer area of 3.7 km or 2 NM. Therefore, the MEYDA holding pattern requires a buffer area of 3.7 km or 2 NM.

2.4.2 Buffer area

2.4.2.1 An additional buffer area extends 9.3 km (5.0 NM) beyond the boundary of the holding area. Significant obstacles in the buffer area are taken into consideration when determining the minimum holding level.

2.4.2.2 For helicopter holding procedures, the buffer area is 3.7 km (2 NM) wide and only applies below 1 830 m (6 000 ft).

Figure 7. Buffer Area (ICAO, 2018)

e. Holding Orientation

At the "MEYDA" holding point, 2 forms of holding point design were carried out, namely Model 1 in the form of a holding point with the direction of the inbound leg 1500 and outbound leg 3300 and also Model 2 holding orientation on the inbound leg 80° and outbound leg at 260°. The test results on each form can be seen in the figure below.

2. Technical Design

As the maturation of the holding pattern planning, it is necessary to design the technical design data of the holding pattern mapping to maximise the feasibility test time. Therefore, the design is designed through the following data:

a. Holding point coordinates: 8°20'59" N and 114°08'48.8" E
b. Holding Level: 3000 feet
c. Distance: 1.7 NM
d. Buffer Area: 2 NM
e. Inbound leg: 1500 /080°
f. Outbound leg: 3300 /260°

3. Holding Pattern Feasibility Test

We conducted the holding pattern feasibility test at the Indonesian Aviator Academy Banyuwangi using a Cessna 172 SP training aircraft. The criteria we tested included aspects of safety, comfort, effectiveness, and impact on student pilots. We adjusted the test procedure to the planning and technical design that we have made before. The holding stages that need to be considered are the entry holding phase, the holding phase, and the approach phase. The feasibility of this trial was carried out 3 times, namely. Before making a flight, the point that has been set coordinates are entered in the Multi-Functional Display (MFD) which is Garmin 1000 by turning the FMS knob to the Way Point page and can input a new way point based on the coordinates that have been designed.

a. PK-APN

This test was conducted on 18 September 2024 at 01.55 UTC using PK-APN aircraft. The test was conducted using inbound pattern 150° and outbound 330°. Entry was carried out on the holding pattern using the teardrop procedure, and the pattern test was successfully carried out

without violating the boundaries of the area and also the existing altitude restrictions set according to Annex 2 Rules of The Air.

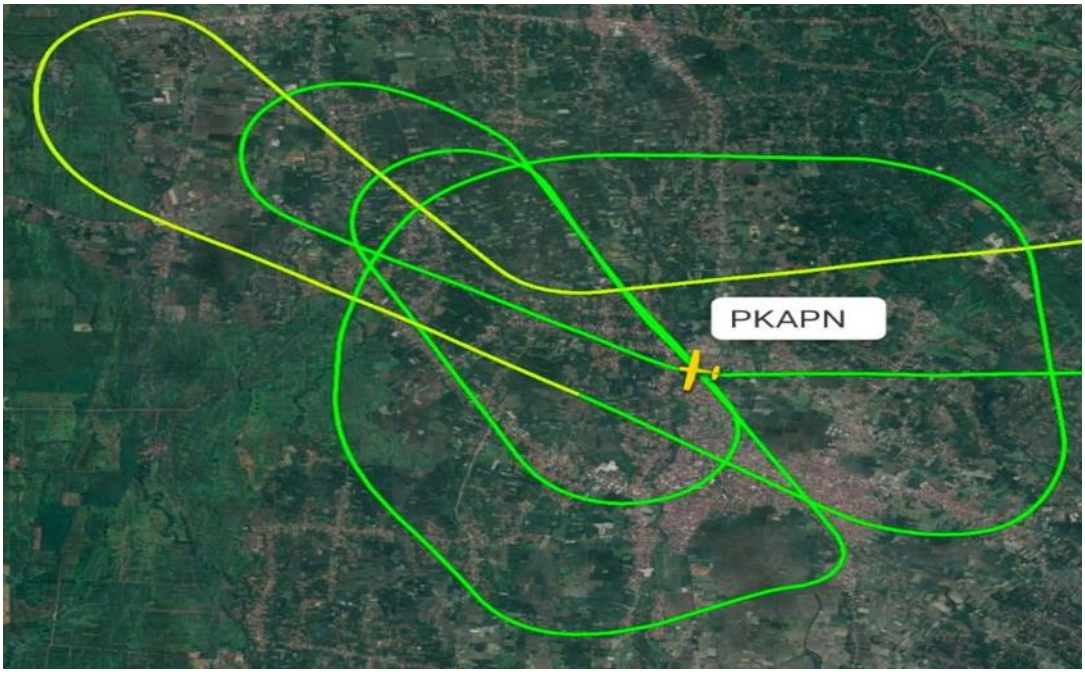

Figure 8. Holding Pattern with Model 1 with aircraft PK - APN based on Flightradar 24 capture.

b. PK-BYS

This test was conducted on 20 September 2024 at 05.00 UTC using the PK-BYS aircraft. Testing was carried out using the inbound pattern 150° and outbound 330°. Entry is done first with the teardrop method with an altitude of 3000 feet and do two times holding. Then exit the pattern and try to re-enter with a parallel procedure with an altitude of 1500 feet for once holding. The results of the second trial can be seen in Figure 9 below. In this holding area and direction, there are several challenges related to wind direction and speed. When turning in the inbound direction, the aircraft was hit by a strong northeast wind (± 11 Knots) that pushed the aircraft and made the aircraft not turn perfectly. See Figure 9.

Figure 9. Holding Pattern with Model 1 with Garmin 1000 data view on Google Earth.

c. PK-BYJ

This test was conducted on 23 September 2024 at 07.00 UTC using PK-BYJ aircraft by testing the 2nd Model, namely inbound 080° and outbound 260°. Entry is done first with a parallel method with an altitude of 3000 feet by holding 3 times. The results of the second trial can be seen in Figure 10 below.

Figure 10. Holding Pattern with Model 2 with Garmin 1000 data view on Google Earth.

Testing has been carried out 3 times, and from the Garmin data processor that has been converted to KML, simultaneous input is made on each model. The result of the joint input is that a fixed point is found which becomes a reference for the implementation of the holding pattern at coordinates 8°20'59"S and 114°08'48.8"E which is named "MEYDA". More details can be seen in Figure 11 below.

Figure 11. Holding Pattern with Models 1 and 2, with Garmin 1000 data view on Google Earth.

DISCUSSION

The trial results show that the use of the "MEYDA" point for the implementation of holding with a holding pattern is possible even though it uses 2 forms, namely in Model 1 (inbound 150° and outbound 330°) or Model 2 (inbound 080° and outbound 260°). However, since the main reason for using a holding point is for the approach process, Model 2 would be more effective for the holding process and the implementation of the Initial Approach Procedure for IFR landings (Eisenhut et al., 2011). (Eisenhut et al., 2021; Nehme et al., 2021; Wang et al., 2018).

Holding points basically function as a way for airspace management, where aircraft that will land are placed at certain points that are used for holding (delay) while reducing altitude (losing altitude). (Bin Mohammed Salleh et al., 2018; Lee et al., 2011; Lopez et al., 2009). In the implementation of holding, aircraft altitude

and speed must also be considered to keep passengers comfortable while the aircraft is maneuvering. (Itoh & Mitici, 2019; Lui et al., 2020; Sedláčková et al., 2020). The holding altitude and speed can be seen in Table 1 below.

Table 1. Classification of speed and holding duration by altitude (Source: ICAO Doc 8168)

Altitude	Speed		Outbound and Inbound Duration
	Normal Condition	Turbulance Condition	
Below 6.000 feet	100 kt	100 kt	1 minute
6.000 – 14.000 feet	170 kt	170 kt	1 minute
14.000 – 20.000 feet	240 kt	280 kt or 0,8 Mach	1 minute or 1,5 minute
20.000 – 34.000 feet	265 kt	280 kt or 0,8 Mach	1 minute or 1,5 minute

Holding points are also an initial reference point to aim for as a direction in the approach. (Samà et al., 2019). When the aircraft is holding, the best pattern formed is when the inbound heading is in line with the runway azimuth, thus facilitating the approach while organizing the landing sequence (Bayen et al., 2004; Chakrabarti & Vela, 2020). (Bayen et al., 2004; Chakrabarti & Vela, 2020). In this case, Model 2 (inbound 080° and outbound 260°) is the main choice, because it is in the same direction as the runway azimuth of Banyuwangi Airport, namely 080° (for runway 08). So that the inbound heading on the holding pattern is in line with the runway for the long final approach. (Asmayawati & Nixon, 2020; Ng et al., 2017).

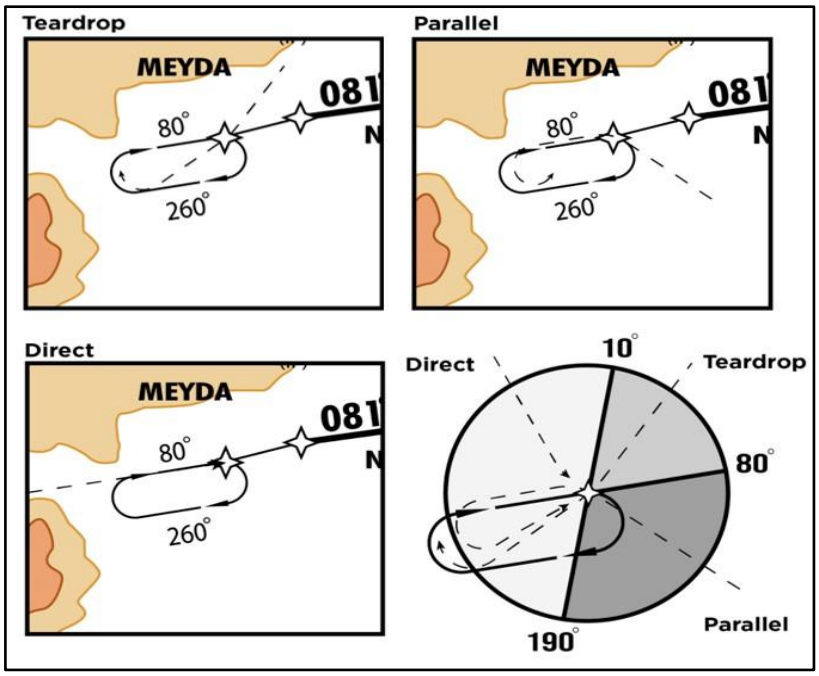

Figure 12. Holding Pattern Entry Procedure at Point "MEYDA"

Figure 12 illustrates that in model 2 (inbound 080° and outbound 260°), all entry procedures can be done either parallel, teardrop or direct. The entry procedure can be selected according to the direction of arrival of the aircraft at the point towards the north of the earth. For direct procedures, it can be done if the aircraft comes from the direction of 191° to 10°, while for parallel procedures it is done if the direction of arrival of the aircraft is from 081° to 190°, while the teardrop procedure is done if the aircraft comes from the direction of 011° to 080°. In the approach process both by instrument and visual (long final) there is a decent/approach procedure at each point or point that is up to the runway. The altitude drop procedure at point "MEYDA" up to runway 08 Banyuwangi Airport can be seen in Figure 13 below.

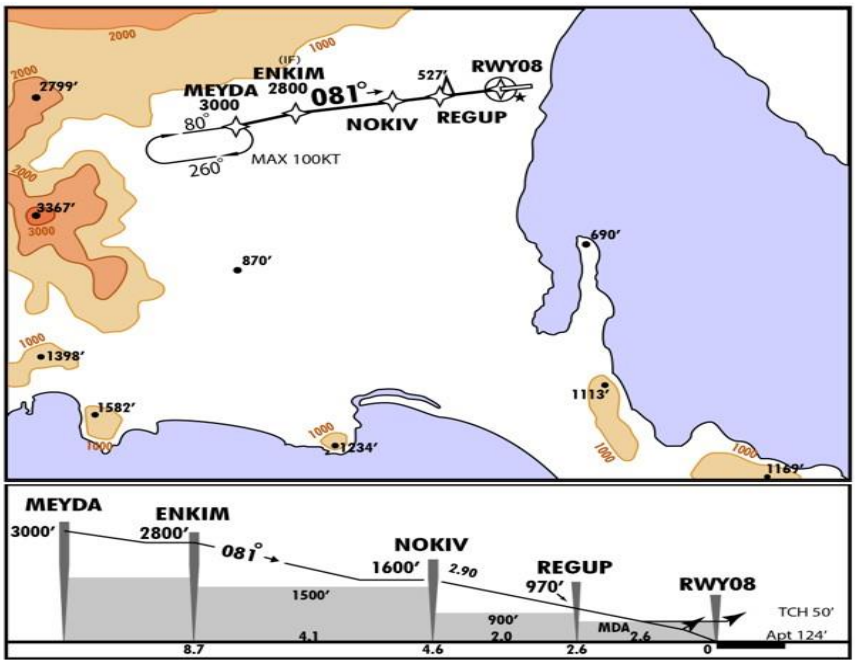

Figure 13. Approach Procedure

The results of this study also illustrate that Instrument Rating flight training on the landing stage can also be carried out at Banyuwangi Airport by using the "MEYDA" reference point for the holding implementation. In the implementation of holding, an altitude reduction is carried out which then approaches based on the points registered in the Garmin 1000 on the Cessna 172 SP aircraft owned by API Banyuwangi. The use of reference points based on coordinates is also possible when the aircraft is equipped with adequate equipment such as GPS or Garmin 1000 (Eisenhut et al., 2021; Lui et al., 2020).

CONCLUSION AND RECOMMENDATION

The implementation of aircraft holding at certain points is one form of airspace management. Holding is not only used to provide sequencing, delay, but also allows aircraft to reduce altitude to a certain limit to make a landing. Training in the instrument rating phase for API Banyuwangi student pilots, especially for instrument landings can be done in the Banyuwangi Airport area.

The Genteng area can be used as an aircraft maneuver holding location because it has several strategic advantages. Geographically, the area provides a large and safe airspace for flight training, allowing aircraft to maneuver safely without disturbing commercial flight paths as well as other training flights. The reference holding point is 8°20'59" N and 114°08'48.8" E with the code "MEYDA". The feasibility test results show that 2 holding pattern models can be used, namely Model 1 (inbound 150° and outbound 330°) and Model 2 (inbound 080° and outbound 260°). For the holding (delay) training process followed by an instrument approach procedure (IAP), Model 2 (inbound 080° and outbound 260°) is the most feasible model to become a holding pattern at the "MEYDA" point.

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