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Original research article

Preparation of Navigation Plan for Scenic Routes Between Airports at Bangkok(VTBD) and U-Tapao (VTBU) and Validation Using Flight Simulator

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ABSTRACT

A navigation plan is an integral part of the airline dispatch operations which helps and guides the pilot by providing all of the information needed for the safe flight to reach a destination. It must be framed with the utmost focus to provide the most accurate data and information so that the pilot can follow the scheduled time. There are n- number of possible routes to reach a destination with a flight. In this research, a flight plan for finding the most scenic route between Don Mueang International airport(VTBD) and U-Tapao International airport(VTBU) is done along with the simulation of the route with the help of a flight simulator. Here visual flight rules are used to make flight plans for a Cessna 172R aircraft and the navigation plan is completely simulated with redbird 2 flight simulator.

Keywords: Flight Simulator; Navigation plan; Scenic routes; Thailand; Tourism

1. Introduction

This research topic explores the preparation of a navigation plan using visual flight rules between Bangkok's Don Mueang International airport (VTBD) and Rayong's U-Tapao International airport(VTBU), and uses a flight simulator to validate the navigation plan for scenic routes which can be used for the purpose of tourism. The goal of this research is to provide a low altitude flight so that most of the landmarks can be seen while flying between two of the famous tourist destinations in Thailand. Additionally, the research will also give a comprehensive understanding of the role of flight simulators in flight planning and will identify opportunities for improvement and innovation in this area.

The remainder of this paper is organized as follows: Section 2 is the literature review done to find the gaps in researches, Section 3 introduces the methodology used to find all the parameters that are necessary and included in flight plan; Section 4 presents the flight simulation done using Redbird 2; finally,

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Section 5 shows the results based on the flight simulation to find the best scenic route from Bangkok to U-Tapao

2. Literature Review

Feriyanto et al. (2016), compares two kinds of aircraft and tracks by calculating flight distance, flight time and block fuel. In their work, a total of five tracks were done to fly from Jakarta to Denpasar and the fuel required for making the trip with two different aircrafts, Boeing 737-400 and Airbus A320-200 were calculated. They found out that a route that has the following check points CGK-HLM- KASAL-TOC-CA-PIALA-ANY-BA-SBR-RABOL-TOD-TALOT-KUTA-BLI has less flight time and uses less fuel with Airbus A320-200 aircraft [3].

Economic growth exerts a significant influence on the transportation system, encompassing land, sea, and air travel. Notably, air travel, or the use of airplanes, has witnessed a global increase in demand.

Various airline companies have responded by introducing new routes and enhancing their aircraft's amenities to stay competitive in the industry. Concurrently, these companies have adopted diverse aircraft models, such as Boeing, Airbus, Bombardier (Canada), Sukhoi, CASA, and others. Consequently, each airline has carefully considered their financial strategies.

The introduction of new flight routes offers business opportunities to the general public. For example, destinations previously reachable only by land travel can now be accessed more quickly through new flight routes, contributing to improved economic growth. However, airlines must be mindful of setting flight fares in line with consumer purchasing power. Hence, airlines face the critical decision of selecting the right aircraft for their operations.

X Z Yang et al. (2020) proposed a method of establishing a flight path planning surrogate model based on stacking ensemble learning, which can solve the real-time problem of complex flight mission's on-line waypoints calculation. Offline flight samples are produced using flight mission characteristics as input and a sequence of flight waypoint coordinates as output. Subsequently, a two-tier coupling model is formed through a stacking ensemble learning approach. A range of base-learners is established to acquire information about the number of waypoints and the coordinates of each waypoint individually. Finally, a surrogate model for flight path planning is constructed by amalgamating all the base- learners, thereby creating a direct mapping between the input and output. The outcomes indicate that this surrogate model proficiently computes aircraft flight waypoints while also ensuring exceptional accuracy and real-time capability [1].

The study conducted by M Y Pasudan et al. (2017) had a primary objective to identify the most efficient waypoints for the flight route.

The proposed methodology includes the following steps: 1. Employ Agglomerative Hierarchical Clustering (AHC) to segment the route into distinct sections, based on the geographical coordinates (latitude and longitude) of each waypoint. 2. Utilize the coefficient of cophenetic correlation (c) to assess the correlation between the waypoints within each cluster, providing insight into the relationships between them. 3. Implement cubic spline interpolation to create a graphical representation that connects the coordinates of each waypoint, aiding in visualizing the route's trajectory. 4. Calculate the Euclidean distance to quantify the distances between waypoints, taking into account the results of the AHC clustering, which identifies two centroids for comparison. By incorporating these methods, the study aims to determine the optimal flight route waypoints and better understand the spatial relationships between them, thereby enhancing flight route planning and efficiency [5].

Mou (2021) conducted an in-depth examination of the classification and utility features of navigable airspace, as well as a comprehensive analysis of the methodologies and criteria for various navigable airspace planning approaches, seeking to establish a foundational understanding of navigable airspace management. The goal is to identify the critical parameters essential for navigable airspace, paving the way for the development of a navigable airspace planning and management system anchored in Geographical Information (Ge) technologies. This system will not only offer a practical framework for navigating airspace but also serve as a vital reference for technical aspects and effective means for airspace planning. By addressing issues related to airspace planning, efficient airspace utilization, and low-altitude surveillance, this study aims to resolve pressing concerns and challenges in airspace management [6].

3. Methodology

The Pilot Operating Handbook of Cessna 172R is used extensively to collect data like True airspeed (TAS), Indicated airspeed (IAS), Compass card of Cessna 172R aircraft, and to calculate the parameters in the flight plan like wind correction angle, total fuel required, take-off and landing performance.

Visual Flight Rules (VFR) is used for selection of track. There are n- number of possible tracks that can be drawn from Don Mueang International Airport (VTBD) to U-Tapao International Airport (VTBU). The tracks are drawn based on the combination of taking off and landing from each of the runways and also considering the scenic visuals that can be seen along the route. There are four runways (21R/03L and 21L/03R) and two runways (18/36) in the Don Mueang International Airport and U-Tapao International Airport. In this work, a total of four tracks were prepared, taking into consideration the runways available at the departure airport and destination airport as mentioned in the table, and including the checkpoints and restriction and prohibited zones of flying. The checkpoints were chosen carefully so that they can be seen by the pilot from the altitude at which the aircraft is flying. A flight plan with navigation log which includes the parameters that are necessarily required for the flight between the departure and destination airport is calculated. NOTAMs that were issued by the AEROTHAI for the period of November 2023 were used. The NOTAMs provide the information concerning the safety, efficiency and regularity of flight operations. As a part of the flight simulation, NOTAMs are reviewed and taken into consideration while preparing the flight plan to have the current information affecting the route, departure and destination airports.

Table 1. The proposed Tracks for flying from Don Mueang International airport(VTBD), Bangkok to U-Tapao International airport(VTBU), Pattaya.

Tracks	Takeoff runway	Landing runway	Checkpoints
Track 1	21R or 21L	36	VTBD - Chaophraya river - Ancient city - Koh Sichang - Between Koh larn and Pattaya city - Koh Chuang - VTBU
Track 2	21R or 21L	18	VTBD - Chaophraya river - Ancient city - Koh Sichang - Intersection of Highways 36 and 331 - VTBU
Track 3	03R or 03L	36	VTBD - Dream world - Chaophraya Estuary - Koh Sichang - Intersection of Highways 36 and 331 - VTBU
Track 4	03R or 03L	18	VTBD - Dream world - Intersection of Highway 7 and 9 - Chaophraya Estuary - Koh Sichang - Koh Larn - Koh Chuang - VTBU

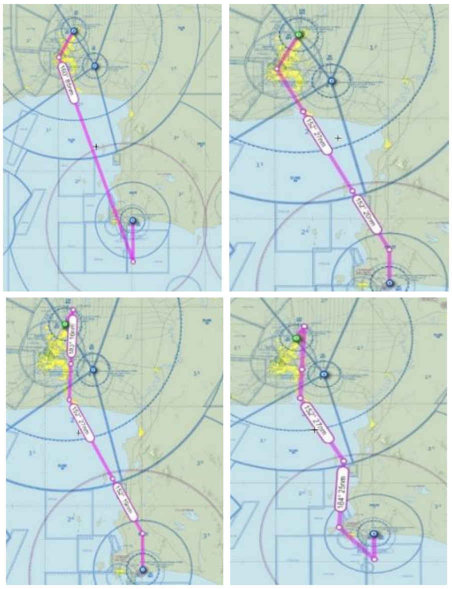

Fig. 1. Showing clockwise from the top left the Track 1, Track 2, Track 3 and Track 4 to be used for flying from Don Mueang International airport(VTBD) to U-Tapao International airport(VTBU).

Since in VFR, the flying altitude is not assigned by the Air Traffic Control (ATC), the flying altitude is chosen based on the restrictions mentioned in the sectional aeronautical charts of Thailand's airspace. The flying altitude differs for each track but the maximum altitude for flying is kept at 4000 ft above Mean Sea Level (MSL).

For True Air Speed (TAS) to be maintained during takeoff and cruising under standard temperature of 15˚C is obtained from the Pilot Operating Handbook of Cessna 172 R aircraft.

Wind correction angle is neglected since the flight simulation will be done taking no weather effects into consideration. So, the value of True Heading will be equal to the value of True Course.

A Magnetic Variation of 0.87˚W is prevailing in and around the Bangkok area. But for the calculation of Magnetic Heading, the Magnetic Variation is rounded off to the nearest whole number and taken as 1˚W.

For calculating the Compass heading that must be followed while flying, Magnetic Deviation is obtained for the calculated Magnetic Heading, from the Compass card of a Cessna 172R aircraft.

Magnetic Heading and Compass Heading are calculated by using the following:

Magnetic Heading = True Heading ± Magnetic Variation, (3.1)

Compass Heading = True Heading ± Magnetic Deviation. (3.2)

Navigation log showing Check points, flight altitude, True Air Speed (TAS), True Course (TC), True Heading (TH), Magnetic Variation (VAR), Magnetic Heading (MH), Magnetic Deviation (DEV) and Compass Heading for each track are calculated and tabulated for use during the flight simulation.

Table 2. Track 1 taking off from runway 21R or 21L of Don Mueang International Airport to runway 36 of U-Tapao International airport.

CHECK POINTS	ALTITUDE(FEET)	TAS (KNOTS)	TC	TH	MH	COMPASS HEADING
			WCA	VAR	DEV	
DON MUEANG(VTBD)	2000	77	210 0	210 1	211 4	215
CHAOPHRAYA RIVER	3000	112	160 0	160 1	161 -2	159
ANCIENT CITY	4000	111	160 0	160 1	161 -2	159
KOH SICHANG	4000	111	160 0	160 1	161 -2	159
BETWEEN KOH LARN AND PATTAYA CITY	4000	111	160 0	160 1	161 -2	159
KOH CHUANG	2000	112	0 0	0 1	1 0	1
U- TAPAO(VTBU)						

Table 3. Track 2 taking off from runway 21R or 21L of Don Mueang International Airport to runway 18 of U-Tapao International airport.

CHECK POINTS	ALTITUDE(FEET)	TAS (KNOTS)	TC	TH	MH	COMPASS HEADING
			WCA	VAR	DEV	
DON MUEANG(VTBD)	2000	77	210 0	210 1	211 4	215
CHAOPHRAYA RIVER	3000	112	152 0	152 1	153 -2	151
ANCIENT CITY	4000	111	152 0	152 1	153 -2	151
KOH SICHANG	4000	111	152 0	152 1	153 -2	151
INTERSECTION OF HIGHWAYS 36 & 331	2000	112	180 0	180 1	181 1	182
U- TAPAO (VTB)						

Table 4. Track 3 taking off from runway 03R or 03L of Don Mueang International Airport to runway 18 of U-Tapao International airport.

CHECK POINTS	ALTITUDE(FEET)	TAS (KNOTS)	TC	TH	MH	COMPASS HEADING
			WCA	VAR	DEV	
DON MUEANG(VTBD)	2000	77	30 0	30 1	31 -3	28
DREAMWORLD	3000	112	183 0	183 1	184 1	185
INTERSECTION OF HIGHWAYS 7 & 9	4000	111	183 0	183 1	184 1	185
CHAOPHRAYA ESTUARY	4000	111	152 0	152 1	153 -2	151
KOH SICHANG	4000	111	152 0	152 1	153 -2	151
INTERSECTION OF HIGHWAYS 36 & 331	2000	112	180 0	180 1	181 1	182
U- TAPAO(VTBU)						

Table 5. Track 4 taking off from runway 03R or 03L of Don Mueang International Airport to runway 36 of U-Tapao International airport.

CHECK POINTS	ALTITUDE(FEET)	TAS (KNOTS)	TC WCA	TH VAR	MH DEV	COMPASS HEADING
			30	30	31	
DON MUEANG(VTBD)	2000	77	0	1	-3	28
DREAMWORLD			183	183	184	
	3000	112	0	1	1	185
INTERSECTION OF HIGHWAYS			183	183	184	
7 & 9	4000	111				185
			0	1	-2	
CHAOPHRAYA ESTUARY			152	152	153	
	4000	111	0	1	-2	151
KOH SICHANG			184	184	185	
	4000	111	0	1	1	186
KOH LARN			139	139	140	
	4000	111	0	1	-2	138
KOH CHUANG			0	0	1	
	2000	112				1
U- TAPAO(VTBU)			0	1	0	

4. Flight Simulation

In flight simulation, all the necessary flight activities that include starting the aircraft, taxiing, ground-roll, take-off, ascending to the desired altitude, steady flight with forward motion, following the drawn route, descending and approaching the runway at the destination airport, landing, breaking and stopping the aircraft are carried out to replicate and simulate the experience of flying an aircraft. Even though the simulator does not replicate the actual terrain of the areas through which the aircraft is flying, it is sufficiently accurate to display significant landmarks and provide reliable information about the flight path. All the flights were simulated with ideal weather conditions of clear skies, no turbulence and no gusts. In the simulator, the originating airport is set to Don Mueang International Airport. The cruising is done with 80% power and an engine speed 2200RPM is mostly maintained throughout the flight to have the desired and calculated climb and cruise performance. The flight in the simulator was operated manually without the assistance of available autopilot systems, and upon reaching each check point, adjustments were made by manipulating control surfaces such as the rudder and ailerons to follow the desired flight path at each check points.

4.1 Track 1

The following figures show panoramic view of each check point along Track 1.

Fig. 2. Panoramic view of Check Point 1 – VTBD along Track 1.

Fig. 3. Panoramic view of Check Point 2 – Chaopraya river along Track 1.

Fig. 4. Panoramic view of Check Point 3 – Ancient City along Track 1.

Fig. 5. Panoramic view of Check Point 4 – Koh Sichang along Track 1.

Fig. 6. Panoramic view of Check Point 5 – Between Koh Larn and Pattaya city along Track 1.

Fig. 7. Panoramic view of Check Point 6 – Koh Chuang along Track 1.

Fig. 8. Panoramic view of Check Point 7 – VTBU along Track 1.

4.2 Track 2

The following figures show panoramic view of each check point along Track 2.

Fig. 9. Panoramic view of Check Point 1 – VTBD along Track 2.

Fig. 10. Panoramic view of Check Point 2 – Chaophraya river along Track 2.

Fig. 11. Panoramic view of Check Point 3 – Ancient city along Track 2.

Fig. 12. Panoramic view of Check Point 4 – Koh Sichang along Track 2.

Fig. 13. Panoramic view of Check Point 5 – Intersection of Highways 36 and 331 along Track 2.

Fig. 14. Panoramic view of Check Point 5 – VTBU along Track 2.

4.3 Track 3

The following figures show panoramic view of each check point along Track 3.

Fig. 15. Panoramic view of Check Point 1 – VTBD along Track 3.

Fig. 16. Panoramic view of Check Point 2 – Dreamworld along Track 3.

Fig. 17. Panoramic view of Check Point 3 – Chaophraya estuary along Track 3.

Fig. 18. Panoramic view of Check Point 4 – Koh Sichang along Track 3.

Fig. 19. Panoramic view of Check Point 5 – Intersection of Highways 36 and 331 along Track 3.

Fig. 20. Panoramic view of Check Point 6 – VTBU along Track 3.

4.4 Track 4

The following figures show panoramic view of each check point along Track 4.

Fig. 21. Panoramic view of Check Point 1 – VTBD along Track 4.

Fig. 22. Panoramic view of Check Point 2 – Dreamworld along Track 4.

Fig. 23. Panoramic view of Check Point 3 – Intersection of Highway 7 and 9 along Track 4.

Fig. 24. Panoramic view of Check Point 4 – Choaphraya estuary along Track 4.

Fig. 25. Panoramic view of Check Point 5 – Koh Sichang along Track 4.

Fig. 26. Panoramic view of Check Point 6 – Koh Larn along Track 4.

Fig. 27. Panoramic view of Check Point 7 – Koh Chuang along Track 4.

Fig. 28. Panoramic view of Check Point 8 – VTBU along Track 4.

5. Result and Discussion

Figs. 2-28 show the visuals as seen from the cockpit of the aircraft while passing through check points in each track. The visuals of each track are compared. The following description provides a visual understanding of the different flight paths and the areas they cover, allowing us to distinguish between the scenic experiences offered by each track.

In the initial check points of Track 1 and Track 2, the aircraft is flying over central and south eastern parts of city of Bangkok reaching the Gulf of Thailand, then flying over the island of Koh Sichang. Then the tracks divert, in which the flight taking Track 1 is covering the sceneries of beaches in Pattaya city, Island of Koh larn, Koh Chuang and nearby islands, whereas the flight taking Track 2 flies over the landscapes of Pattaya reaching the airport at U-Tapao.

In the initial check points of Track 3 and Track 4, the aircraft is flying over northern, eastern and south eastern parts of Bangkok reaching the Gulf of Thailand, then flying over the island of Koh Sichang. Then the tracks divert, in which the flight taking Track 3 flies over the landscapes of Pattaya, whereas Track 4 is covering the sceneries of beaches in Pattaya city, Island of Koh larn, Koh Chuang and nearby islands reaching the airport at U-Tapao.

6. Conclusion

All four distinct flight tracks offer a vivid portrayal of the diverse, visually attractive and vivid landscapes encountered by aircraft flying over the city of Bangkok and its sub-urban areas. The initial common route, passing over the city and reaching the Gulf of Thailand, provides a breathtaking view of the urban and coastal beauty that Thailand's capital has to offer. As the flight paths diverge, passengers and aviation enthusiasts are presented with a choice: Track 1 and Track 2 lead to unique experiences, with Track 1 highlighting the sandy beaches of Pattaya and its surrounding islands, while Track 2 takes travelers on a journey to the U- Tapao airport.

Track 3 and Track 4 offers a splendid view of both urban and natural terrain then into the Gulf of Thailand. Then after reaching Koh Sichang, Track 3 holds the charming landscapes of Pattaya, whereas Track 4 showcasing the beauty of Pattaya and the nearby island's pleasing beaches then reaching U-Tapao airport.

The main purpose is to show the scenic beauty in the diversified landscapes of Thailand to the tourists based on their interests and the enchanting sights they wish to see. It is also going to be exciting for the tourists to see the landscapes of the capital city of Thailand and the most visited places of Thailand from above and discovering the beauty which pleases their aesthetic senses.

7. Future Scope

In the future, it is suggested that while preparing the flight plan to include calculations of flight time, fuel requirements, integration of actual weather data like METAR and TAF for these routes which will improve the usefulness of the flight plans calculated and simulated in this paper. It is also suggested to have a comparison study on the usage of various aircrafts which belong to the same category of Cessna 172R to fly between these airports.

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