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STUDY ON THE DESIGN OF THE VFR (VISUAL FLIGHT RULES) CORRIDOR CONNECTING AIRPORTS IN NORTH SUMATRA PROVINCE

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ABSTRACT
This research aims to design a VFR Corridor that can connect airports located in the province of North Sumatra, especially those airports that do not yet have a VFR Corridor. The research method used is Research and Development (R&D). Data was collected using observation, literature study, interviews, and documentation. The results showed that the current condition of the VFR Corridor has not connected the eight airports in the North Sumatra region. However, the eight airports can be connected with the new VFR Corridor design consisting of three segments. This design allows VFR aircraft to follow the VFR Corridor path rather than flying direct. In addition, the VFR Corridor design also ensures that the movement of VFR aircraft will not interfere with IFR aircraft following STAR at Kualanamu Airport in Medan and Sisingamangaraja Airport. This study has implications for improving the safety and efficiency of flight operations in the North Sumatra region. With a structured and connected VFR Corridor, VFR aircraft pilots have clearer guidance in air navigation, so the risk of collisions with IFR aircraft can be minimized. In addition, this design also supports the development of aviation infrastructure in North Sumatra, especially in facilitating connectivity between airports that do not yet have a VFR Corridor.

Keywords: VFR, Airports, Visual Flight Rules.

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INTRODUCTION

AirNav Indonesia manages and serves flight navigation in Indonesia's 7,539,693 km2 of airspace following the signing of a bilateral boundary realignment agreement between FIR Jakarta and FIR Singapore on January 25, 2022. It was agreed that flight navigation services in the Riau Islands and Natuna that the Singapore FIR previously carried out would be transferred to the Jakarta FIR. The agreement was then ratified by Presidential Regulation No. 109 of 2022 on the Ratification of the Agreement between the Government of the Republic of Indonesia and the Government of the Republic of Singapore on the Boundary Adjustment between the Jakarta Flight Information Region and the Singapore Flight Information Region (Mithalina & Risnain, 2023). The Indonesian FIR is divided into two, namely:

1. The Jakarta FIR, which covers the western airspace of Indonesia, is managed by the Jakarta Air Traffic Services Center (JATSC) and its subordinate units and
2. The Ujung Pandang FIR, covering the eastern part of Indonesia, is managed by the Makassar Air Traffic Services Center (MATSC) and its subordinate units.

Indonesia's airspace is directly adjacent to several other countries airspace, including Australia (Melbourbe FIR & Brisbane FIR), Sri Lanka (Colombo FIR), Singapore (Singapore FIR), Malaysia (Kuala et al. FIR), Philippines (Manila FIR), United States (Oakland Oceanic FIR), Papua New Guinea (Port Moresby FIR) and India (Chennai FIR) (Azari, 2024). During 2022, every day, AirNav Indonesia served an average of 4,210 aircraft movements, both take-off or landing and overflying flights between countries in Indonesian airspace. The number of flight routes managed by AirNav Indonesia is 181, consisting of 117 domestic and 64 international routes.

Based on the scope of operations, flight navigation services are divided into Aerodrome Control Tower (TWR), Approach Control Unit (APP), Area Control Center (ACC), Aerodrome Flight Information Service (AFIS), and Flight Information Center (FIC). Meanwhile, based on the procedure, the types of services can be divided into Aerodrome Control Tower (TWR), Approach and Area Control Procedural (APP et al.), Approach Control Surveillance (APS), Area Control Surveillance (ACS), and a combination of TWR and APP procedural (combined). A simple profile of the services provided, the location, and the typical airspace served by AirNav Indonesia is illustrated in the following figure (A. Indonesia, 2022); (ERGA, 2023).

Figure 1. Service Unit Profile
Source: Airnav Indonesia Annual Report 2022

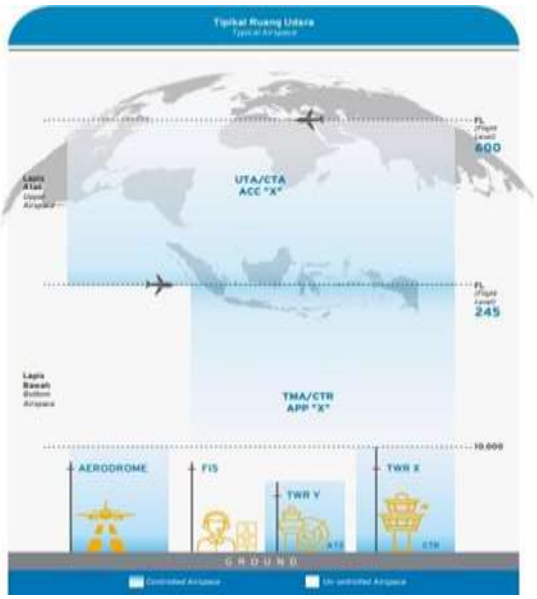

Figure 2. Typical Airspace
Source: Airnav Indonesia Annual Report 2022

Airnav Indonesia has 28 branch offices and 34 sub-branch offices. Perum LPPNPI Medan Branch has several sub-branch offices, namely Gunung Sitoli. Table 1 shows flight traffic at Perum LPPNPI Kualanamu Branch from 2019 to 2023.

Table 1. Domestic Flight Traffic of Kualanamu International Airport

No.	Year	Total Aircraft Departure	Average
1.	2019	2630867	219238.917
2.	2020	1313501	109458.417
3.	2021	1358551	113212.583
4.	2022	2349151	195762.583
5.	2023	2543261	211938.417

Source: Central Bureau of Statistics

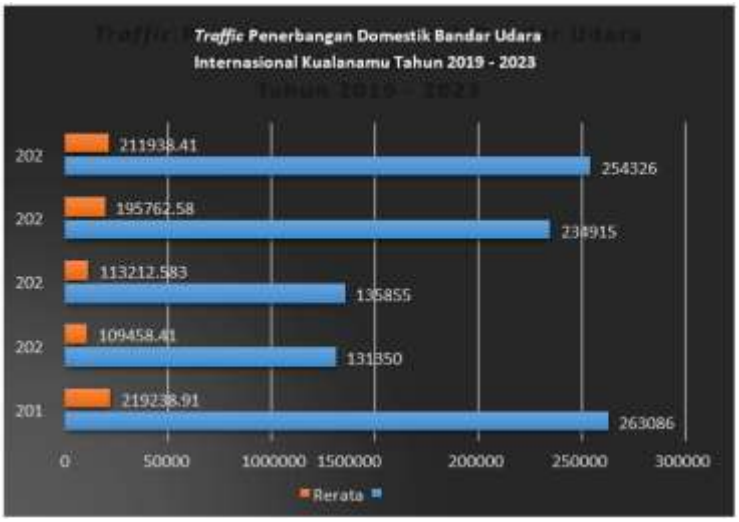

Figure 3. Domestic flight traffic graph

Based on data, Domestic flight traffic in 2023 has not exceeded the existing traffic limit in 2019, but traffic from 2020 to 2023 has increased slowly. In 2020-2021, the impact of COVID-19 is still very much felt, so flights are not maximized.

Table 2. International Flight Traffic of Kualanamu International Airport

No.	Year	Total Aircraft Departure	Average
1.	2019	1090904	90908.66
2.	2020	188473	15706.08
3.	2021	3150	262.5
4.	2022	415270	34605.83
5.	2023	924956	77079.66

Source: Central Bureau of Statistics

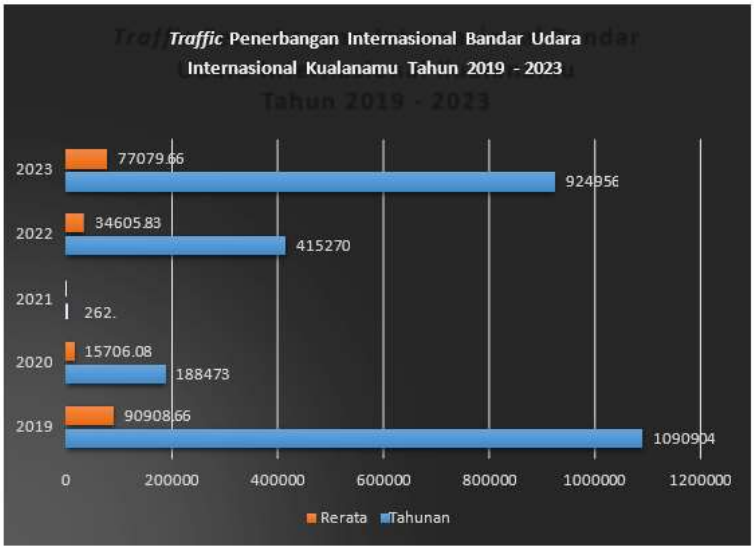

Figure 4. Domestic flight traffic graph

International flight traffic in 2023 did not exceed the existing traffic limit in 2019, but traffic from 2020 to 2023 increased slowly, just like domestic flight traffic. Based on data from the Indonesian Ministry of Transportation Directorate General of Civil Aviation, North Sumatra Province has several airports, which we can see in Table 3.

Table 3. List of Airports in North Sumatra Province

No.	ICAO	IATA	Airport Name	Category	Class	Manager
1.	WIMM	KNO	Kualanamu International	International	Class 1	PT Angkasa Aviation Temple
2.	WIMB	GNS	Binaka	Domestic	Class II	UPT DG Hubud
3.	TIME	AEG	Aek Godang	Domestic	Class III	UPT DG Hubud
4.	WIMS	FLZ	Dr. Ferdinand Lumban Tobing	Domestic	Class III	UPT DG Hubud
5.	WIMO	-	Lasondre	Domestic	Class III	UPT DG Hubud
6.	WIMP	SIW	Sibisa	Domestic	Satpel BU	UPT DG Hubud
7.	-	-	Big Jendra Abdul Haris Nasution	Domestic	BU Satpel	UPT Ditjen Hubud
8.	WIMN	DTB	King Sisingamangaraja XII	Domestic	Non-classroom	UPT Ditjen Hubud

Source : https://hubud.dephub.go.id/hubud/website/bandara

Figure 5. Kualanamu Airport Deli Serdang
Source: (Hubud.dephub.go.id, 2022)

Airnav Kualanamu Medan is an International Airport. International Airports are airports that are designated as airports serving domestic flight routes and flight routes to and from abroad (R. Indonesia, 2009). Since 2022? Kualanamu International Airport is also a Hub Airport. Hub Airports have a wide service coverage of airports that serve large numbers of passengers and cargo and affect economic development nationally or in various provinces (R. Indonesia, 2009).

The type of flight is based on the way of flight, namely instrument flight or instrument flight rules and visual flight or visual flight rules (RI, 2014). Visual Flight Rules (VFR) flight is a method of flight in which the pilot relies on visual sight for navigation rather than relying on flight instruments (Bupu, 2021); (Li et al., 2023). VFR Corridor is a flight path designed to support VFR operations, enabling more efficient and safer flights (Retno & Muchaddats, 2024); (Ahmadi et al., 2022). North

Sumatra, as one of the main provinces in Indonesia, has several airports that play an important role in regional connectivity.

Current conditions in the North Sumatra region based on AIRAC AMDT 86 have 5 Segments. Not all airspace areas in North Sumatra have VFR Corridors, such as the Airport area in Sibolga and the Airport Area in Padang Sidemuan. This study aims to design a VFR Corridor connecting the main airports in North Sumatra, which will pass through several cities as a visual reference and is also equipped with latitude and longitude coordinates. The focus is on mapping the optimal path and potential for aviation development in the region.

Several airports in North Sumatra Province still lack VFR corridors, so the authors are interested in making the title Research Study Design of VFR Corridor Connecting Airports in North Sumatra Province. Based on the background description above, this study aims to design a VFR Corridor that can connect airports located in the province of North Sumatra, especially those airports that do not yet have a VFR Corridor. The benefits of this research are expected to provide a significant contribution to the aviation sector in North Sumatra Province. Firstly, by designing a VFR Corridor, this study will help enhance the safety and efficiency of flight operations, especially for general aviation and small aircraft that rely on visual navigation. Secondly, the implementation of a well-designed VFR Corridor can improve connectivity between airports, which in turn supports regional economic development by facilitating smoother and more reliable transportation of goods and passengers. Lastly, this research could serve as a reference for future studies and the development of aviation infrastructure in other regions of Indonesia, contributing to a more comprehensive and integrated national airspace system.

METHOD

The research method used is Research and Development (R&D). Data is collected through observation, literature study, and interviews with air traffic controller personnel Perum LPPNPI Medan Branch and experts in the field of procedure design and documentation. Data sources include laws, regulations, and ICAO documents such as Document 8168—Procedures for Air Navigation Services, Annexes, and relevant journals.

RESULTS AND DISCUSSION

Description of Research Object

This research focuses on the airspace area without a VFR Corridor design. Table 4 shows the latitude and longitude coordinates at 8 (eight) airports in North Sumatra Province.

Table 4. Geographical Location of the Airport

No.	Airport Name and ID	Location	ARP coordinates		Source
			Latitude	Longitude	
1.	Kualanamu	Deli Serdang District	03°30'16.4 "N	098°36'27.9 "E	AMDT 52/28 APR 16
2.	Binaka	Gunung Sitoli District	01°09'55.0 "N	097°42'22.0 "E	AIRAC AMDT 02/17 (02 MAR 2017)
3.	Sibisa ID: Sibisa	Toba district	02°36'05.0 "N	098°57'47.0 "E	AIRAC AMDT 02/17 (02 MAR 2017)
4.	Dr. Ferdinand Lumbantobing	Kab. Tapanuli Tengah	01° 33' 13" LU	098° 53' 38" WEST	https://hubud.dephub.go.id/hubud/website/bandara/92

No.	Airport Name and ID	Location	ARP coordinates		Source
			Latitude	Longitude	
5.	Aek Godang	Padang Sidempuan District	01° 23' 56" LU	099° 25' 50" WEST	https://hubud.dephub.go.id/hubud/website/bandara/381
6.	King Sisingamangaraja XII	North Tapanuli district	02° 15' 39.93" LU	098° 59' 40.57" BT	https://hubud.dephub.go.id/hubud/website/bandara/66
7.	Lasondre	South Nias Regency	00° 01' 7.95" LS	098° 18' 01.99" BT	AMDT 03/10 NOV 06
8.	Abdul Haris Nasution	Kab. Mandailing Natal	0°56'53.0 "N	99°32'00.0 "E	https://hubud.dephub.go.id/hubud/website/bandara/383

Source: https://app-pia.airnavindonesia.co.id/navearth/
https://hubud.dephub.go.id/hubud/website/bandara

Generally, the flight process is departing, climbing, cruising, descending and landing. Of course, this process is from one airport to another. To connect from one airport to another requires an airway or route. This route is divided into 2 (two): the route to fly instrumentally and visually (Arfiansah et al., 2021). Flying instrumentally and visually has a difference. Instrumentally means relying on the aircraft's instruments, while visually means that the pilot relies on landmarks or visual reference points on the ground. Current conditions in the North Sumatra region based on AIRAC AMDT 86 have 5 Segments, namely in the following table 5:

Table 5. VFR Corridor North Sumatra Current Condition

No.	VFR Corridor	Description
1.	WONDO - INAGA	VFR Corridor connecting point INAGA (Western part of North Sumatra) with point WONDO (Soewondo Air Base)
2.	TEBIN - UPURA	VFR Corridor connecting point UPURA (Tanjung Pura) with point TEBIN (Tebing Tinggi City)
3.	UPURA - WONDO	VFR Corridor connecting point UPURA (Tanjung Pura) with point WONDO (Soewondo Air Base)
4.	KUNAM - WONDO	VFR Corridor connecting point KUNAM (Kuala Namu Airport) with point WONDO (Soewondo Air Base)
5.	KUNAM - SLG VOR/DME	VFR Corridor connecting point KUNAM (Kuala Namu Airport) with point SLG VOR/DME (Silangit Airport)

Source: AIRAC AMDT 86

In North Sumatra, as in the table Table. 5 Geographical Location of Airports above, there are 8 (eight) airports, which means there are still 3 (three) airports that have not been connected. From the data obtained from July - December 2021 to 2023, which can be seen in Table 4.3, aircraft heading to airports that have not been connected to the VFR Corridor, pilots fly directly; this condition disrupts IFR arrival aircraft whose approach follows the predetermined standard arrival (follow profile) to Kualanamu Airport and Raja Sisingamangaraja XII Airport.

Due to VFR aircraft flying directly, IFR aircraft cannot follow the arrival standard and must cancel STAR. Therefore, to anticipate this, it is necessary to design a VFR Corridor to avoid VFR aircraft flying directly or indirectly.

Table 6. VFR Flight Movement Data

No.	Airport Name	Location Indicator	Airport Location	IATA Code	Year		
					Jul - Dec 2021	2022	2023
1.	BINAKA	WIMB	SITOLI MOUNTAIN	GNS	265	580	357
2.	SISINGAMANGARAJA XII	WIMN	SILANGIT	DTB	59	61	107
3.	Dr. FERDINAND LUMBAN TOBING	WIMS	PINANGSORI, CENTRAL TAPANULI	FLZ	102	232	251
4.	LASONDRE	WIMO	TANAH MAS ISLAND, SOUTH NIAS	LSE	300	852	1052
5.	AEK GODANG	WIME	PADANG LAWAS	AEG	2	6	6
6.	SIBISA	WIMP	AJIBATA, TOBA	SIW	48	122	130

Source: KNO Airnav Data

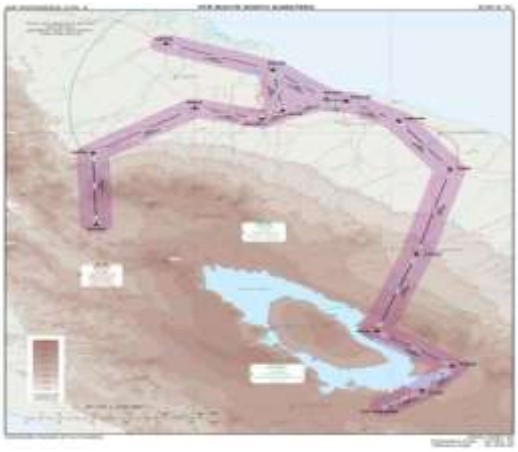

Figure 6. VFR Corridor Current Conditions in North Sumatra

VFR Corridor Design

Coordinate Determination

Coordinates are determined to determine the visual reference point. In this design, coordinates are determined using tools, namely Google Earth Pro, as in Figure 7 below.

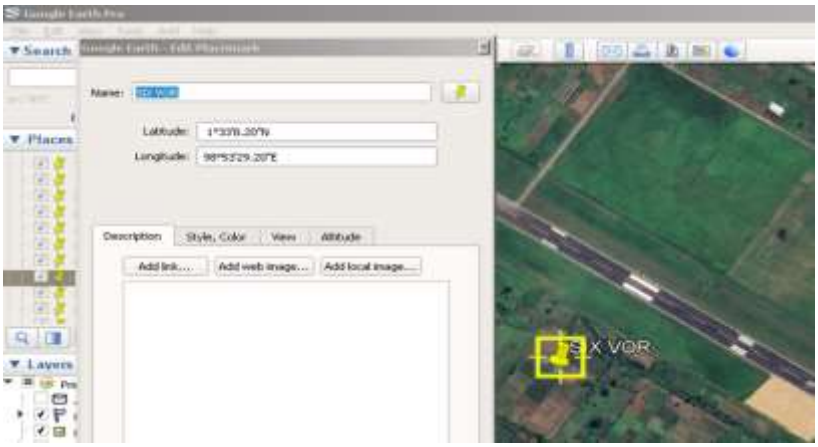

Figure 7. Determination of Coordinates with Google Earth

Table 7. Landmarks and Coordinates

No.	*Point*	*Landmark*	Coordinates
1.	Point A	Stadium Ball	N020123500 E09857576
2.	Point B	Church	N015157700 E09854513
3.	Point C	Square / Field	N014448400 E09846335
4.	Point D	Mursala Waterfall	N014130600 E09827065
5.	Point E	Bintana Island	N012839900 E09810424
6.	Point F	Binaka Airport	N011013000 E09742120
7.	Point G	Sisingamangaraja Airport	N021542600 E09859076
8.	Point H	Soccer Field	N014706400 E09907069
9.	Point I	Field	N013607800 E09916276
10.	Point J	Stadium Ball	N012152400 E09916224
11.	Point K	Aek Jorni Nature Bath	N010922400 E09925216
12.	Point L	AH Nasution Airport	N005653000 E09932000
13.	Point M	FL Lumban Tobing Airport	N013308200 E09853292
14.	Point N	Bridge	N012839500 E09904048
15.	Point O	Aek Godang Airport	N012356000 E09925500

Source: Processed Data

Coordinate Conversion to UTM (Universal Transfers Mercator)

Conversion is an activity to change coordinates from latitude/longitude to UTM using the transport tool (Chevy, 2015). This conversion is carried out with the aim of reading the coordinates specified during the drawing using Autocad. As in Figure 8.

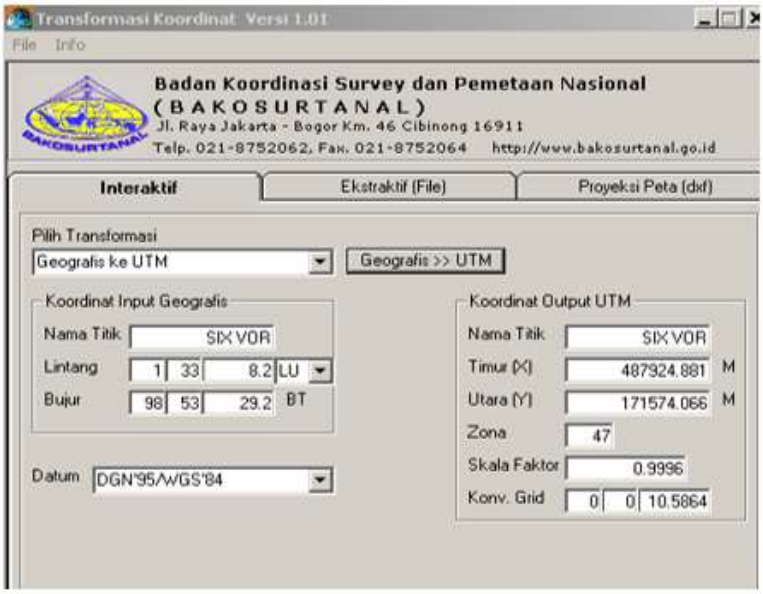

Figure 8. Conversion Process

Plotting Process

The plotting process uses an application on the Autocad web. In this process, each visual reference point or landmark coordinate obtained is entered so that the VFR Route image will appear, as shown in Figure 9. After the VFR Route is drawn, continue to draw the protection area to the right and left of the VFR Route of 5 NM each. The results of this process will produce a VFR Corridor image (Rachman et al., 2021).

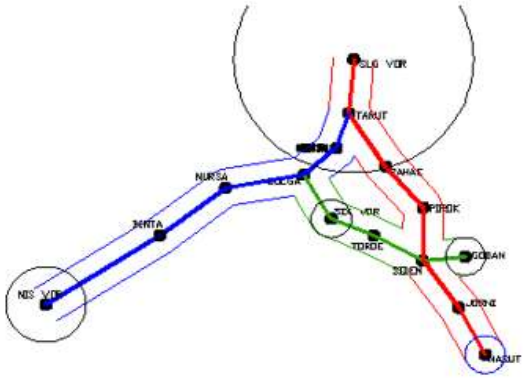

Figure 9. VFR Route Drawing Process

Drawing Track and Distance

Calculating track/direction and distance/distance from each coordinate using Compsyss tools. An example image in the picture below

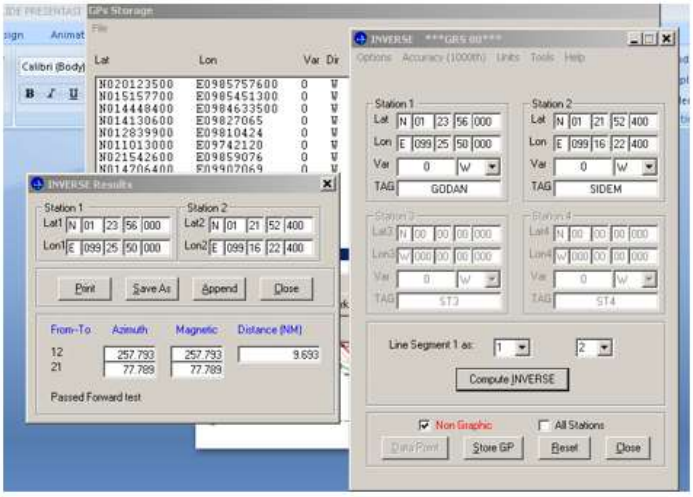

Figure 10. Track and Distance Calculation Process

Table 8. Track and Distance of Sisingamaraja Airport to Binaka Airport

No.	Point Landmark	Track	Distance
1.	Point G to Point A (VV)	184 degrees 004 degrees	14.3 NM
2.	Point A to Point H (VV)	147 degrees 327 degrees	16.9 NM
3.	Point H to Point I (VV)	139 degrees 319 degrees	14.3 NM
4.	Point I to Point J (VV)	180 degrees 360 degrees	14.1 NM
5.	Point J to Point K (VV)	144 degrees 324 degrees	15.3 NM
6.	Point K to Point L (VV)	151 degrees 331 degrees	14.1 NM

Source: Processed Data

Table 9. Track and Distance of Sibolga to Aek Godang Segment Route

No.	Point Landmark	Track	Distance
1.	Point C to Point M (VV)	149 degrees 329 degrees	13.5 NM
2.	Point M to Point N (VV)	112 degrees 292 degrees	11.5 NM
3.	Point N to Point J (VV)	118 degrees 298 degrees	14.0 NM
4.	Point J to Point O (VV)	077 degrees 257 degrees	9.7 NM

Source: Processed Data

Design Results

After all the design processes, the next step is to name each point. In giving names following the five letter name code (5LNC) rules in the ICAO 8168 document, for example, KODAP. KODAP is a significant point not characterized by the location of radio navigation facilities and is therefore given a pronounceable five-letter name code. (ICAO, 2018)The naming also considers the location or place of the point coordinates of the nearest city/district; the point is to make it easier for pilots to recognize the route. Point naming can be seen in Table 10 below.

Table 10. Five Letter Name Code Point Naming

No.	Point	Coordinates	Five Letter Name Code (LNC)
1.	Point A	N020123500 E09857576	TARUT
2.	Point B	N015157700 E09854513	COTTON
3.	Point C	N014448400 E09846335	BOLGA
4.	Point D	N014130600 E09827065	MURSA
5.	Point E	N012839900 E09810424	BINTA
6.	Point F	N011013000 E09742120	NIS
7.	Point G	N021542600 E09859076	SLG
8.	Point H	N014706400 E09907069	PAHAE
9.	Point I	N013607800 E09916276	PIROK
10.	Point J	N012152400 E09916224	SIDEM
11.	Point K	N010922400 E09925216	JORNI
12.	Point L	N005653000 E09932000	NASUT
13.	Point M	N013308200 E09853292	SIX
14.	Point N	N012839500 E09904048	TORRE
15.	Point O	N012356000 E09925500	GODAN

Source: Processed Data

Furthermore, the naming of Five LNC is outlined in Table 11, Table 12, and Figure 4.6 of the design results.

Table 11. Segment A Track and Distance Sisingamaraja Airport to Binaka Airport

No.	Point Landmark	Track	Distance
1.	Point TARUT to Point KOTIN (VV)	198 degrees 018 degrees	9.8 NM
2.	Point KOTIN to Point BOLGA (VV)	229 degrees 049 degrees	10.9 NM
3.	Point BOLGA to Point MURSA (VV)	260 degrees 080 degrees	19.7 NM
4.	Point MURSA to Point BINTA (VV)	232 degrees	20.8 NM

No.	Point Landmark	Track	Distance
5.	Point E BINTA to Point NIS (VV)	052 degrees 237 degrees 057 degrees	33.9 NM

Source: Processed Data

Table 12. Segment B Track and Distance Table Sisinggamaraja Airport to AH Nasution Airport

No.	Point Landmark	Track	Distance
1.	Point SLG to Point TARUT (VV)	184 degrees 004 degrees	14.3 NM
2.	Point TARUT to Point PAHAE (VV)	147 degrees 327 degrees	16.9 NM
3.	Point PAHAE to Point PIROK (VV)	139 degrees 319 degrees	14.3 NM
4.	Point PIROK to Point SIDEM (VV)	180 degrees 360 degrees	14.1 NM
5.	Point SIDEM to Point JORNI (VV)	144 degrees 324 degrees	15.3 NM
6.	Point JORNI to Point NASUT (VV)	151 degrees 331 degrees	14.1 NM

Source: Processed Data

Table 13. Segment C Track and Distance Table Sisinggamaraja Airport to AH Nasution Airport

No.	Point Landmark	Track	Distance
1.	Point BOLGA to Point SIX (VV)	149 degrees 329 degrees	13.5 NM
2.	Point Six to Point TOROE (VV)	112 degrees 292 degrees	11.5 NM
3.	Point TOROE to Point SIDEM (VV)	118 degrees 298 degrees	14.0 NM
4.	Point SIDEM to Point GODAN (VV)	077 degrees 257 degrees	9.7 NM

Source: Processed Data

Figure 11. VFR Corridor Design of North Sumatra Airport

CONCLUSION

This research concludes that the existing VFR Corridor in North Sumatra Province does not currently connect the eight airports in the region. However, through this study, a new VFR Corridor design has been proposed, consisting of three segments that effectively link these airports. The new design provides a structured pathway for VFR aircraft, ensuring they can navigate the corridor rather

than flying directly between airports. Additionally, the proposed VFR Corridor design is carefully planned to ensure that the movements of VFR aircraft will not interfere with IFR operations, particularly those following the Standard Terminal Arrival Routes (STAR) at Kualanamu Airport in Medan and Sisingamangaraja Airport. This design aligns with the research objectives of enhancing connectivity and ensuring safe and efficient air traffic management in the region..

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