Analysis Approach on Travel Time due to Changes on Airport Network Function

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ABSTRACT : The plan to expand the service of the airport in the province of North Borneo will be executed in 2020 and 2030. The expansion planning would affect the routes and network existing of air transportation in the province of North Borneo. The change on route networks will affect to function and travel time between the existing routes. This study aims to determine the suitability of the existing condition of the airport in the form of the distance between the airport and the change of travel time due to changes in the function of the airports. The distance between the airport will be determined through the coordinate data of each airport and calculated using distance analysis based on Euclidean distance. The results are then drawn into the distance matrix. Travel time of each route includes the process of taking off, climbing, cruising, descending, approaching, and landing. Changing routes also affect the passenger travel time between cities. The result indicates that travel time and travel cost before and after changing on airport function bring some divergence.

***Keywords** : airport function, distance matrix, travel time*

1. Introduction

Tarakan city is the center of air transportation in the province of North Borneo. Juwata airport in Tarakan represents the largest airport in the province of North Borneo. The status of interactional airport is designated by runway classification, which is 4D. The function of Juwata international Airport is a hub airport. Tanjung Harapan is another airport in the capital of province with runway classification 3C and its function as a feeder airport (spoke). Each capital of regency/municipalty in the province of North Borneo has one airport, except regency of Tana Tidung. The classification of runway 2B is applied in those airports and has a role as feeder airports (spoke). The development plan of the airport in the year 2020 and 2030 for the province of North Borneo will affect the conditions of air transportation in the respected province. The plan changes the function, the pattern of airport operations, air traffic, passenger movements, travel time, as well as travel expenses (Ministry of Transportation, 2013). This research is intended to determine the suitability of the existing condition, such as the distance between the aerodrome with the Regulation of the Minister of Transport 69 in 2013 related to minimum distance between airports. The evaluation then is continued to examine the effect in changing the function of the airports to travel time and direct operational cost of airlines served in the province of North Borneo. Therefore, the

results of this study could be one of the inputs to the development plan of the airport in the province of North Borneo.

2. Literature References

2.1 Network Pattern

Network is a collection of nodes connected by arc. Pattern of air transportation network is generally shaped as a grid pattern, line pattern, and hub and spoke pattern. Grid pattern is a pattern in a zona that is adopted to the central zone interlink with sub-zone. Line pattern is a pattern in interlink network from a central to sub-zone that is relatively away from the center of the zone. Hub and spoke pattern is a network pattern to have the shape of as chicken scratch. This pattern has a zone between the central zones, where there are interlinks with the subzone of the service area (Nasution, 2008).

2.2 Distance

A function that is referred to a distance has the nature of non-negative ($d_{ij} \geq 0$) and ($d_{ij} = 0$) if i = j, symmetry ($d_{ij} = d_{ji}$). The length of one side of the triangle is always less than or equal to the sum of two other sides ($d_{ij} \leq d_{ik} + d_{jk}$) (Purnamasari, 2011). Several methods in determining the distance that is commonly used in the analysis (Purnamasari, 2011):

a. Euclidean Distance

$$d_{ij} = \sqrt{\sum_{k}^{p} 1\{x_{ik} - x_{jk}\}^2} \quad (1)$$

b. Manhattan Distance

$$d_{ij} = \sum_{k=1}^{p} |x_{ik} - x_{jk}| \quad (2)$$

c. Pearson Distance

$$d_{ij} = \sqrt{\sum_{k=1}^{p} \frac{(x_{ik} - x_{jk})^2}{vap(x_k)}} \quad (3)$$

d. Correlation Distance

$$d_{ij} = 1 - r_{ij} \quad (4)$$

e. Absolute Correlation Distance

$$d_{ij} = 1 - {}_{j} | r_{ij} | \quad (5)$$

Assuming that the Euclidean distance between the two variables have not correlated to each other, have the same units of measurement. Measurement standard has an average of zero, and a standard deviation equal to one. Euclidean distance is the distance between objects, for example two objects to- i and j are located in dimensional p. Distance measurement on this research generally uses euclidean distance calculation method (Maylana, 2008).

2.3 Phase of Flight

Phase of flight comprised of take off, climbing, cruising, descend, approach, landing, holding, and go-around (Saputra, etc, 2015, Hutagaol, 2013, Swatton, 2008). Holding is only conducted when it is required, usually due to congestion at the destination airport. Another cause is bad weather conditions that is causing aborted landing (go-around) to go to the alternate airport (Nasution, 2008). In obtaining the number of flying hours can be used several methods of calculation that is: block off to block on or block hours. The first calculation is based on the time since the machine is turned on and chock the wheels (block) is released at the place of origin/ departure until landing at the destination and chock the wheels are installed and the engine turned off. The second method of calculation is period when the aircraft airborne to touch down, that since the plane take off when the wheels left the runway, until landing when the wheels touched the runway at the destination.

2.4 Operational Cost

The basic rate obtained from result of the average of basic cost per unit production plus profit (Ministry of Transportation, 2010). Basic cost consists of two cost components, those are:

- direct cost, consist of fixed cost and variable costs.
- indirect cost, consist of the organization cost and marketing costs.

Basic cost is total operational cost of an aircraft. This is based on the full cost including a maximum profit level of 10%. Aircraft operating expenses are used as the basis for determining the basic tariff . The distance tariff is the average cost of all types of aircraft operated by the airlines. Cost per unit is costs per kilometer passenger that is derrived from the total operational cost of aircraft with a load factor of 65% for the jet aircraft and 70% for the propeller aircraft.

3. Research Data

3.1 Existing Condition

Tale 1 presents data of existing airports which are located in capital of municipality/city in the province of North Borneo.

Table 1. Airport location and existing classification

No	The Name of Airport	City/ Location	IATA Code	Function	Classification
1	Kol. R. A Bessing	Malinau	MLN	Spoke	2B
2	Tanjung Harapan	Tanjung Selor	TJS	Spoke	3C
3	Nunukan	Nunukan	NNX	Spoke	2B
4	Juwata	Tarakan	TRK	Hub	4D

The airports observed in this research are located in capital of the municipality/city in the province of North Borneo as showed in Figure 1.

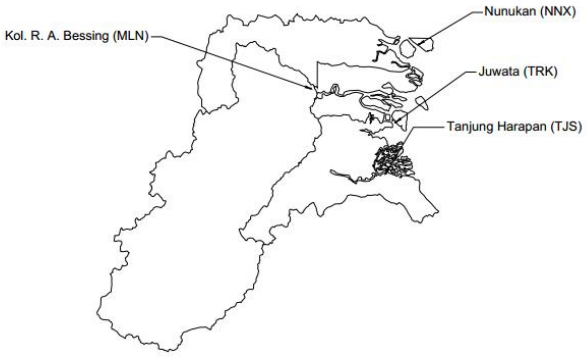

Figure 1. Airport location

3.2 National Masterplan for Airports

Airport will be developed according to the national master plan. The distance between two airports needs to follow the criteria listed in Table 2 (Ministry of Transportation, 2013). In this study, airports studied located in the island of Borneo, therefore, the coverage area per airport is 60 km or the distance between the two airports is 120 km. The indicators of fulfillment of the criteria is the distance or travel time attainment of land transport modes or other modes that can be served by the airports. Changes to existing condition and the plan (2020 and 2030) for airports that were observed in this study can be seen in the following table 3.

Table 2. Criteria and indicator of airport coverage

Area	Criteria	Indicator
Java Island and Sumatera Island	Coverage of 100 km or two airports within 200 km.	Distance / time achievement land transport modes or other modes that can be served for an airport on a specific area.
Borneo Island and Celebes Island	Coverage of 60 km or two airports within 120 km.	Distance / time achievement land transport modes or other modes that can be served for an airport on a specific area
Bali, Nusa Tenggara, Maluku Islands, dan Papua Island	Coverage of 30 km or two airports within 60 km	Distance / time achievement land transport modes or other modes that can be served for an airport on a specific area.

Table 3. Changes to airport existing condition and the plan (2020 and 2030)

No	The Name of Airport	City/ Location	Airport Function			IATA Code
			Existing	2020	2030	
1	Kol. R. A Bessing	Malinau	Spoke	Spoke	Spoke	MLN
2	Tanjung Harapan	Tanjung Selor	Spoke	Tertiary Hub	Secondary Hub	TJS
3	Nunukan	Nunukan	Spoke	Tertiary Hub	Tertiary Hub	NNX
4	Juwata	Tarakan	Tertiary Hub	Secondary Hub	Secondary Hub	TRK

Figures 2 and 3 show the route of air transport on existing condition, and changes route of air transport due to changes in the function of airports in the province of North Borneo.

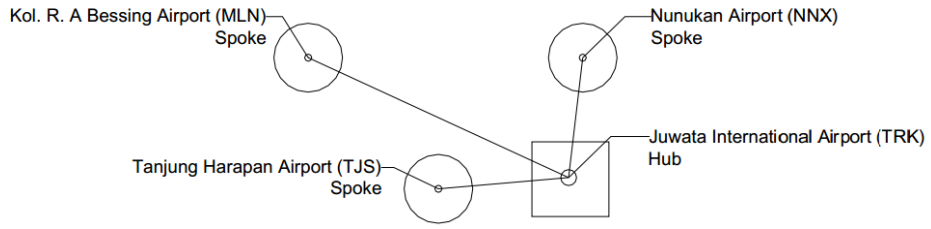

Figure 2. Route of air transport on existing condition

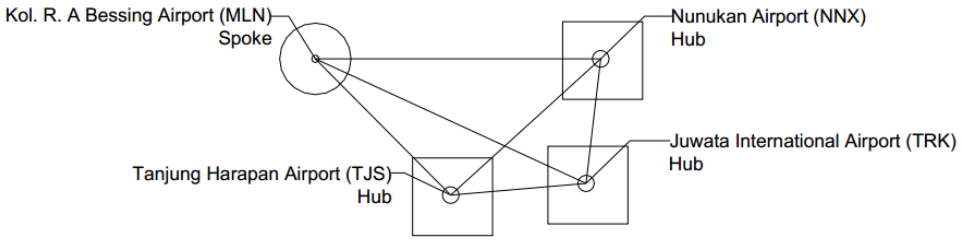

Figure 3. Route of air transport (2020 and 2030)

Service flights on Figure 2 shows an internal flight route in the province of North Borneo centered on the airport Juwata. This is because the function of airports Juwata as a hub airport. The plan to increase the status of Tanjung Harapan airport and Nunukan airport in 2020 and 2030 give effect to the internal flight route in the province of North Borneo, it gives effect to the distance and time to both the passenger and the airlines. Changes in this flight distance drive impact on the operational cost of aircraft.

3.3 Airport Coordinates

Coordinate data of each aerodrome obtained from secondary data, through the Aeronautical Information Publication of Indonesia and publication of the Ministry of Transport of the Republic of Indonesia. Coordinate data mentioned above will be converted into the coordinates of the Universal Transverse Mercator (UTM) to the value of units of distance (meters), which then be compiled into a distance matrix

Table 4. Coordinate of airports

The Name of Airport	Location	IATA Code	Decimal Coordinate	
			Latitude	Logitude
Robert Atty Bessing	Kab. Malinau	MLN	3,583	116,633
Tanjung Harapan	Kab. Bulungan	TJS	2,837	117,374
Nunukan	Kab. Nunukan	NNX	4,133	117,667
Juwata	Kota Tarakan	TRK	3,327	117,569

3.4 Aircraft Perfomance

Airline scheduled conducting an internal flight in the province of North Borneo use ATR 42-300 aircraft. Table 5 shows data of the performance of aircraft type ATR 42-300:

Table 5. ATR 42-300 performance

Peformance	ATR 42-300			
	Speed		Distance	
Take off	108	Knots	3576	ft
Climbing	160	Knots	25000	ft
Cruising	266	Knots	-	ft
Descent	120	Knots	25000	ft
Landing	103	Knots	3389	ft

Aircraft performance data mentioned above will be used to analyze the approach to the travel time of the aircraft.

3.5 Passenger Fare

Determination of the tariff is based on the value of the basic fare passenger aircraft multiplied by distance traveled. Passenger tariff was strongly influenced by the cost of aircraft operations. To determine the best operating costs, the amount of passenger fares for internal flights province of North Borneo indispensable in Annex IV Ministerial Decree No. 26 of 2010, is as follows:

Table 6. Passenger fare

No	Route	Passenger Fare
1	Malinau - Tarakan	Rp 355.000,00
2	Nunukan - Tarakan	Rp 403.000,00
3	Tanjung Selor - Tarakan	Rp 189.000,00

4. Results and Discussions

4.1 Distance Matrix

Before determining the distance of each airport in the province of North Borneo, airports coordinate data will be converted to UTM (Universal Transverse Mercator) coordinates. Table 7 presents the results of the conversion of UTM coordinates:

Table 7. Conversion of UTM coordinates

The Name of Airport	Location	ATA Code		UTM (Universal Transverse Mercator)	
				X	Y
				m	m
Robert Atty Bessing	Kab. Malinau	MLN	Zone 50 N	459278	396077
Tanjung Harapan	Kab. Bulungan	TJS		541585	313575
Nunukan	Kab. Nunukan	NNX		573993	456894
Juwata	Kota Tarakan	TRK		563260	367717

Because the value of UTM have in meters, the value of x and y are converted into units of kilometers and compiled into a distance matrix.

Table 8. Distance Matrix

X		MLN	TJS	NNX	TRK
		459,278	541,585	573,993	563,260
MLN	459,278				
TJS	541,585				
NNX	573,993				
TRK	563,260				

By using the formula obtained euclidean distance from each airport are:

Table 9. Euclidean distance

Distances		MLN	TJS	NNX	TRK
		km	km	km	km
MLN	km	0			
TJS	km	116,5	0		
NNX	km	129,8	146,9	0	
TRK	km	107,8	58,3	89,3	0

Criteria distance between airports to the island of Borneo and Sulawesi is ≥ 120 km. Results of these calculations above show that only the distance between the MLN-NNX and TJS-NNX that meet the criteria for MLN-NNX = 129,8 km ≥ 120 km, and TJS-NNX = 146,9 km ≥ 120 km.

4.2 Travel Time

The travel time is calculated based on flight phase and based on service flights. For travel time to the takeoff phase of flight, climbing, descent, and landing do not change either the existing condition as well as in the plan. Changes occur when cruising this is due to the route and the flight distance, as in the calculation below:

- Take Off = 200,016 km/hour x 1,090 km = 0,327 minute
- Climbing = 296,32 km/hour x 15,24 km = 3,086 minute
- Cruising, cruising time is determined on a distance of each airport will be shown at the table.
- Descent = 222,224 km/hour x 8,800 km = 2,375 minute
- Landing = 190,756 km/hour x 1,033 km =0,325 minute

For cruising time can be seen in the following table: (Table 10)

Table 10. Cruising time in existing condition

Existing			2020 dan 2030		
TRK					
MLN	10,126	Minute	MLN	16,240	Minute
TJS	4,102	Minute	TJS	10,216	Minute
NNX	7,939	Minute	NNX	14,052	Minute
NNX					
TJS	12,041	Minute	TJS	14,896	Minute
MLN	18,065	Minute	MLN	12,813	Minute
TJS					
MLN	14,229	Minute	MLN	11,193	Minute

It takes about an internal flight in the province of North Borneo in the existing condition are:

Tabel 11. Travel time in existing condition

Existing Condition		MLN	TJS	NNX	TRK
		minute	minute	minute	minute
MLN	minute	0			
TJS	minute	26,5	0		
NNX	minute	30,3	24,3	0	
TRK	minute	16,2	10,2	14,1	0

It takes about an internal flight in the province of North Borneo in the plan (2020 and 2030) are:

Table 12. Travel time in 2020 and 2030

2020 and 2030		MLN	TJS	NNX	TRK
		minute	minute	minute	minute
MLN	minute	0			
TJS	minute	17,3	0		
NNX	minute	18,9	21,0	0	
TRK	minute	16,2	10,2	14,1	0

Table 12 shows significant changes in travel times for service flights MLN-TJS, MLN-NNX, and TJS-NNX. This is due to direct flights to airports with higher function.

4.3 Operational Costs

Passenger fare set based on basic costs plus a profit margin of 10% (Swatton, 2008). Aircraft propeller used for load factor of 70%, so it can be written:

Passenger Fare = Operational Cost + 10% Profit

- Route TJS-TRK, distance = 58,3 km, passenger fare = Rp. 189.000, Seat capacity = 50 Seat 70% x 50 = 35 Seat x Rp. 189.000/Seat = Rp. 6.615.000, Operational Cost = Rp. 6.013.636
- Route NNX-TRK, distance = 89,8 km, passenger fare = Rp. 403.000, Seat capacity = 50 Seat, 70% x 50 = 35 Seat x Rp. 403.000/Seat = Rp.14.105.000, Operational Cost = Rp. 12.822.727
- Route MLN-TRK, distance = 107,8 km, passenger fare = Rp. 355.000, Seat capacity = 50 Seat, 70% x 50 = 35 Seat x Rp. 355.000/Seat = Rp. 12.425.000, Operational Cost = Rp. 11.295.454.

From the above calculation results, an average operating cost of aircraft for internal flights in the province of North Borneo = Rp. 3774.00 /passenger-km. Based on the mileage for each

condition (existing and year plan), the obtained cost of aircraft operations is presente in Table 13.

Table 13. Operational cost of aircraft in existing condition (2020 and 2030)

		MLN	TJS	NNX	TRK
		IDR	IDR	IDR	IDR
MLN	IDR	0			
TJS	IDR	21.942.897 (15.395.426)	0		
NNX	IDR	26.104.408 (17.152.664)	19.570.321 (19.411.450)	0	
TRK	IDR	14.238.491 (14.238.491)	7.704.405 (7.704.405)	11.865.916 (11.865.916)	0

Table 13 shows that the year plan operational cost as stated in brackets for some routes are reduced. With these changes, aviation services enterprises (airlines) can benefit by decreasing the operational cost for internal flight route in the province of North Borneo.

5. Summary

Discussion of the results showed that, the distance between the airports in the province of North Borneo in general do not meet the criteria to be implemented in the form of function changes of improvements of some airports status. However, positive influences in the form of saving travel time and cost of aircraft operations may drive mobility in respected province.

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