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Optimization and Flight Schedules of Pioneer Routes in Papua Province

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Abstract. The province of Papua has a very varied topography, ranging from swampy lowlands, hills, and plateaus up steep hills. The total area of land is 410,660 km², which consists of 28 counties and one city, 389 districts and 5.420 villages. The population of Papua Province in 2017 was 3.265.202 people with an average growth of 4.21% per year. The transportation services is still low, especially in the mountainous region, which is isolated and could only be reached by an air transportation mode, causing a considerable price disparity between coastal and mountainous areas. The purpose of this paper is to develop the route optimization and pioneer flight schedules models as an airbridge. This research is conducted by collecting primary data and secondary data. Data is based on field surveys; interviews; discussions with airport authority, official government, etc; and also from various agencies. The analytical tools used to optimization flight schedule and route are analyzed by add-in solver in Microsoft Excel. The results of the analysis we can get a more optimal route so that it can save transportation costs by 7.26%.

1. Introduction

One of the biggest challenges of development implementation in Papua Province is the limited transportation infrastructure which is smooth and cheap, allowing people and government to carry out their activities effectively and efficiently. There are several things that are often mentioned as the reason for poor transportation infrastructure in Papua. First, the extent of Papua Province especially when compared with its residents who live in isolated and scattered. Secondly, the costly cost of building Papua's transport infrastructure is particularly linked to the very difficult geophysics of Papua - in particular the steep mountains of central Papua and the swamps and peatlands of the South. Third, the policy of development of unfair and unfair communications infrastructure so far, for example between coastal areas and inland/mountains.

Papua's natural wealth potential is huge, especially in mining, forestry, plantation, fishery, energy and tourism sectors. But ironically, this great natural resource does not bring prosperity to the people in Papua. This is due to the limited number of infrastructure and transportation facilities which resulted in low accessibility of the region and the isolation and impact on the price of goods and the price of basic needs in the province is relatively much more expensive than the price in other areas in Indonesia due to the very expensive transportation costs.

In 2015, in Papua Province there are 73 pioneer aviation routes financed from APBN funds totaling Rp. 145.702.193.999, -. The number of routes and pioneering air subsidy funds is always increasing from year to year. More details can be seen in Figure 1.



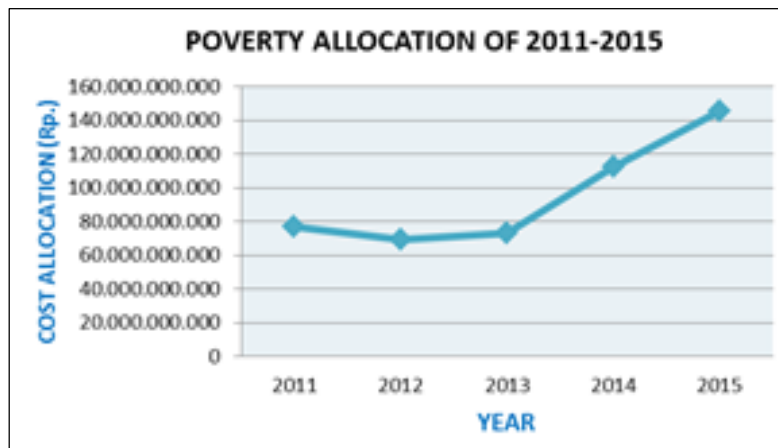


Figure 1. Graph of Development of Pioneer Air Transportation Subsidy in Papua Province in 2011 – 2015

The expected benefits of this research are as input for Papua Provincial Government for the development of pioneer transportation network as an airbridge in Papua Province and provide input for further research related to the development of pioneer aviation routes and schedules in Papua Province.

2. Literature Review

Based on the hierarchy service, the flight route consists of major flight routes, feeders and pioneers. (Regulation of the Minister of Transportation No. KM 49 Year 2005). The main route is the route that connects the central airport deployment. The feeder route is a route that links between a central airport dispersal with an airport that is not a deployment center. Pioneer route is a route that links the airport rather than a dispersal center with an aerodrome rather than a dispersed center located in an isolated (lagging) area.

Pioneer air transport is a commercial air transport that serves networks and aviation routes to connect remote and inland areas or areas hard to contact by other modes of transport, and covertly not profitable for airlines. (Law No. 1 Year 2009 About Aviation).

Air transport activities on pioneer routes shall be made using aircraft with capacity under 30 (thirty) seats. In addition, because most of the pioneer airports have a short runway that can only be landed by small aircraft.

Pioneer Air Transportation is the provision of transportation services where there is government interference in the form of subsidy because there is an imbalance between demand and supply. This pioneering air transport occurs in remote areas where the purchasing power (effective purchasing power) of the community is under the current rate of transportation services. Currently the policy of subsidizing pioneer air transport is based on only one criterion: operational criteria (operating income less than operational cost).

As mentioned above that pioneer aviation operations receive government interference in the form of subsidies. The subsidy is based on the following considerations:

- a. Meet the criteria for the implementation of pioneer air transport
- b. The airport is capable of serving pioneer air transport flights
- c. The airline is ready for operation
- d. Availability of funds from the Central Government and/or Local Government.

While the pioneer route, set by considering:

- a. To connect remote or inland areas;
- b. To foster regional growth and development;

c. To realize the stability of state defense and security.

Some types of travel routes can be expressed, ie (a) resembling chicken claws, (b) spider web, (c) is a straight line and (d) a combination of chicken and straight line models. (Adisasmita, S. A., 2013. Mega City & Mega Airport). Some of these types of flight routes are shown in the following figure:

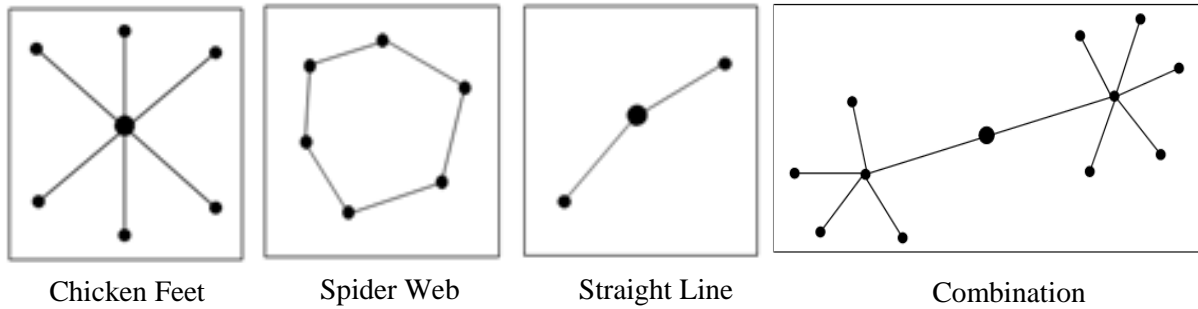


Figure 2. Flight Route Pattern

The scope of this study is limited to the subject of pure flight operations flight schedules with known Origin-Destination (OD), various types of aircraft, fleet size and data-related costs. Although the scheduling process in practice is closely related to aircraft maintenance and ship crew scheduling processes, this process is generally separated to facilitate troubleshooting.

2.1 Overview of Solver Program

The program solver is an add-in program under the excel program. This solver program contains the commands that serve to perform analysis of optimization problems. When installing installing microsoft excel is not automatically this solver is installed, so it must be installed specifically after the excel program installed in the computer. The Excel Solver is a product developed by Frontline Systems for Microsoft. OpenSolver has no affiliation with, nor is recommend by, Microsoft or Frontline Systems.

The program solver can be used in Windows 98, Windows 2000, Microsoft XP, Millennium, Windows Vista, Windows 7, Windows 8 and Windows 10.

3. Data And Analysis

3.1. Subsidies of pioneer air transport in Papua Province

Based on data from Coordination Meeting of Pioneer Air Transportation Year 2015 as shown in table 2, it is seen that the amount of fund allocation for pioneer air transport subsidy in Papua Province continues to increase. In 2011-2014 in Papua Province there are 5 (five) Budget User Authorities (KPA), with the following funding allocations:

Table 1. Allocation of Pioneer Air Transport Funds Papua Province

No	KPA	BUDGET ALLOCATION (Rp. / Year)				
		2011	2012	2013	2014	2015
1	KPA JAYAPURA	13.504.920.000	11.798.072.000	11.198.528.000	12.439.057.000	15.588.173.333
2	KPA MERAUKE	14.413.779.000	10.305.640.000	11.958.988.800	33.231.073.000	43.249.910.000
3	KPA NABIRE	16.954.995.000	15.959.586.000	15.631.756.800	15.192.602.000	19.467.653.333
4	KPA TIMIKA	23.044.091.000	24.496.062.000	27.234.758.027	37.559.229.000	40.154.876.667
5	KPA WAMENA	8.902.202.000	6.966.274.000	7.042.252.800	13.820.951.000	22.700.157.333
5	KPA OKSIBIL					4.541.423.333
TOTAL		76.819.987.000	69.525.634.000	73.066.284.427	112.242.912.000	145.702.193.999

Source: Pioneering Air Transportation Coordination Meeting of 2015

Table 2. Route Pioneer Cargo Air Transport, 2017

ROUTE	TIMIKA	WAMENA	DEKAI
Timika – Beoga	X		
Timika – Ilaga	X		
Timika – Kenyam	X		
Timika – Sinak	X		
Wamena – Mugi		X	
Wamena – Mapenduma		X	
Wamena – Enggolok		X	
Wamena – Mamit		X	
Dekai – Silimo			X
Dekai – Korupun			X
Dekai – Anggruk			X
Dekai – Ubahak			X

Table 3. Minimum Target Pioneer Cargo Air Transport, 2017

NO	REGIONAL COORDINATOR	ROUTE			MINIMUM TARGET	
					MOVEMENT PER WEEK	CONTAINED CARGO PER WEEK (Kg)
1	TIMIKA	Timika	-	Ilaga	4	2000
		Ilaga	-	Timika	4	0
		Timika	-	Sinak	4	3200
		Sinak	-	Timika	4	0
		Timika	-	Kenyam	3	2250
		Kenyam	-	Timika	3	0
		Timika	-	Beoga	3	1500
		Beoga	-	Timika	3	0
2	WAMENA	Wamena	-	Mugi	1	500
		Mugi	-	Wamena	1	0
		Wamena	-	Mamit	1	500
		Mamit	-	Wamena	1	0
		Wamena	-	Mapenduma	1	500
		Mapenduma	-	Wamena	1	0
		Wamena	-	Enggolok	1	500
		Enggolok	-	Wamena	1	0
3	DEKAI	Dekai	-	Anggruk	3	2400
		Anggruk	-	Dekai	3	0
		Dekai	-	Silimo	3	2400
		Silimo	-	Dekai	3	0
		Dekai	-	Korupun	4	1600
		Korupun	-	Dekai	4	0
		Dekai	-	Ubahak	4	2000
		Ubahak	-	Dekai	4	0

Table 4. Results Without Optimization with Solver on Excel

AIRPORT HUB	COST (Rp.)												WAREHOUSE CAPACITY
	ILAGA	SI NAK	KENYAM	BEOGA	MUGI	MA MIT	MPDU MA	ENGG OLOK	ANGG RUK	SILI MO	KORU PUN	UBAH AK	
TIMIKA	10.200	13.200	16.400	9.900	16.500	19.800	15.300	17.000	28.600	22.800	30.600	29.200	10.000
WAMENA	14.800	12.700	8.700	17.300	6.400	8.100	8.300	8.000	5.600	4.200	9.300	6.300	5.000
DEKAI	22.900	229	12.600	25.600	14.000	18.500	15.000	18.000	7.200	7.400	4.600	7.000	5.000
DEMAND	2.000	3.200	2.250	1.500	500	500	500	500	2.400	2.400	1.600	2.000	

DISTRIBUTION (UNIT)	ILAGA	SI NAK	KENYAM	BEOGA	MUGI	MA MIT	MPDU MA	ENGG OLOK	ANGG RUK	SILI MO	KORU PUN	UBAH AK	TOTAL DISTRIBUTION
TIMIKA	2.000	3.200	2.250	1.500	-	-	-	-	-	-	-	-	8.950
WAMENA	-	-	-	-	500	500	500	500	-	-	-	-	2.000
DEKAI	-	1.600	-	-	-	-	-	-	2.400	2.400	1.600	2.000	8.400
TOT.DISTRIBUTION	2.000	3.200	2.250	1.500	500	500	500	500	2.400	2.400	1.600	2.000	
	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	
DEMAND	2.000	3.200	2.250	1.500	500	500	500	500	2.400	2.400	1.600	2.000	
DIFFERENCE	-	-	-	-	-	-	-	-	-	-	-	-	
TOTAL COST (Rp.)	186.190.000												

3.2. Route optimization with solver on excel

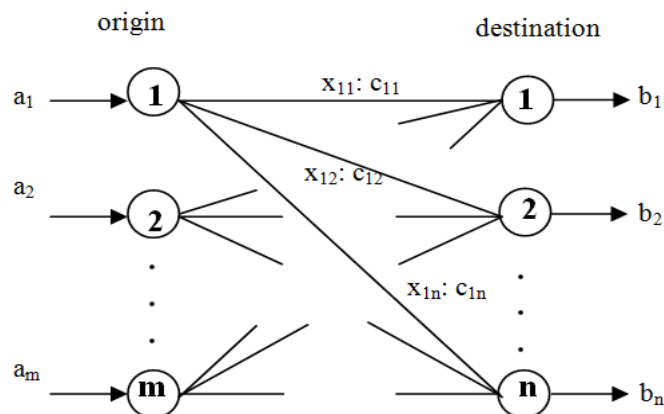


Figure 3. Route optimization with solver on excel

The terms of completion with the transport model is the model in a balanced state, namely:
 Total supply = total demand

$$\sum_i a_i = \sum_j b_j \tag{1}$$

Thus if $\sum_i a_i = \sum_j b_j$ then all the existing supply will be distributed out, and all the request of the destination. Then the source constraints and goal constraints become in the form of equations. Models of transportation of the problem:

$$\text{o.d } \min Z = \sum_i \sum_j c_{ij} x_{ij}$$

$$\text{d.c : } \sum_j x_{ij} = a_i \quad i = 1, 2, \dots, m \tag{2}$$

$$\sum_i x_{ij} = b_j \quad j = 1, 2, \dots, n \tag{3}$$

$$\sum_i a_i = \sum_j b_j \tag{4}$$

$$x_{ij} \geq 0 \quad i = 1, 2, \dots, m$$

$$j = 1, 2, \dots, n$$

Using the solver program on Microsoft excel, then obtained the optimum route optimization results are as follows:

Table 5. Results Optimization with Solver on Excel

AIRPORT HUB	COST (Rp.)												WAREHOUSE CAPACITY
	ILAGA	SI NAK	KENY AM	BEO GA	MUGI	MA MIT	MPDU MA	ENGG OLOK	ANGG RUK	SILI MO	KORU PUN	UBAH AK	
TIMIKA	10.200	13.200	16.400	9.900	16.500	19.800	15.300	17.000	28.600	22.800	30.600	29.200	10.000
WAMENA	14.800	12.700	8.700	17.300	6.400	8.100	8.300	8.000	5.600	4.200	9.300	6.300	5.000
DEKAI	22.900	229	12.600	25.600	14.000	18.500	15.000	18.000	7.200	7.400	4.600	7.000	5.000
DEMAND	2.000	3.200	2.250	1.500	500	500	500	500	2.400	2.400	1.600	2.000	

DISTRIBUTION (UNIT)	ILAGA	SI NAK	KENY AM	BEO GA	MUGI	MA MIT	MPDU MA	ENGG OLOK	ANGG RUK	SILI MO	KORU PUN	UBAH AK	TOTAL DISTRIBUTION
TIMIKA	2.000	1.600	2.250	1.500	500	500	500	500	-	-	-	-	9.350
WAMENA	(0)	-	-	-	-	-	-	-	2.400	2.400	-	200	5.000
DEKAI	(0)	1.600	-	-	-	-	-	-	-	-	1.600	1.800	5.000
TOT.DISTRIBUTION	2.000	3.200	2.250	1.500	500	500	500	500	2.400	2.400	1.600	2.000	
	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	
DEMAND	2.000	3.200	2.250	1.500	500	500	500	500	2.400	2.400	1.600	2.000	
DIFFERENCE	-	-	-	-	-	-	-	-	-	-	-	-	
TOTAL COST (Rp.)	172.676.400												

Prior to the optimization, the cost required for air cargo transportation is Rp. 186.190.000,- per week, while after the optimization of the required cost to be Rp. 172,676,400,- per week so there is a cost savings of 7.26% every week. The results of the route optimization can be seen in the following table 6:

Table 6. The results of the route optimization

NO	REGIONAL COORDINATOR	ROUTE			MINIMUM TARGET	
					MOVEMENT PER WEEK	CONTAINED CARGO PER WEEK (Kg)
1	TIMIKA	Timika	-	Ilaga	4	2000
		Ilaga	-	Timika	4	0
		Timika	-	Sinak	2	1600
		Sinak	-	Timika	4	0
		Timika	-	Kenyam	3	2250
		Kenyam	-	Timika	3	0
		Timika	-	Beoga	3	1500
		Beoga	-	Timika	3	0
		Timika	-	Mugi	1	500
		Mugi	-	Timika	1	0
		Timika	-	Mamit	1	500
		Mamit	-	Timika	1	0
		Timika	-	Mapenduma	1	500

		Mapenduma	-	Timika	1	0
		Timika	-	Enggalok	1	500
		Enggalok	-	Timika	1	0
2	WAMENA	Wamena	-	Anggruk	1	500
		Anggruk	-	Wamena	1	0
		Wamena	-	Silimo	1	500
		Silimo	-	Wamena	1	0
		Wamena	-	Ubahak	1	200
		Ubahak	-	Wamena	1	0
3	DEKAI	Dekai	-	Sinak	2	1600
		Sinak	-	Dekai	3	0
		Dekai	-	Korupun	2	1600
		Korupun	-	Dekai	2	0
		Dekai	-	Ubahak	2	1800
		Ubahak	-	Dekai	2	0

4. Summary

The condition of transportation facilities and infrastructure in Papua Province, especially in the Papua remote area is still very poor. Some areas in the mountains of Papua can only be reached by airplane. This is what causes the price of goods in the region is very expensive because of the very high transportation costs.

Solver Excel through linear programming will make it easier for the decision makers to set policies to determine appropriate routes and schedules to optimize the cost of existing subsidies every year. Solver Excel will be very easy to complete the optimization problem than the manual counting. By using the program solver on Microsoft excel, then we can obtain a more optimal route so that can save transportation costs of 7.26%.

5. References

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