Route and Flight Schedule at the Airport Hub in East Kalimantan Province with MADAM

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Abstract— *Arrangements for routes and flight schedules are needed to provide effective and efficient services to passengers using air transportation services, especially in metropolitan areas with two or more airports. The concept is known as the Multi Airport System, which provides the following advantages: (1) reducing density at primary airports while increasing the capacity of regional air transportation systems. (2) Maintaining the quality of services, especially in primary airports, breaks down and reduces the effects of disruptions that may occur in airport operations. (3) Providing alternative travel options for people in the metropolis to minimize the distance and travel time to the airport. (4) Generating economic activities in the surrounding area, such as increased employment, tax revenue, attracting new companies, and others. (5) Reducing the impact of a service monopoly which could appear at any time in a single airport system. The research finds differences in flight frequencies between exiting conditions and simulation at SAMS airport of Sepinggan Balikpapan by using the Multiple Airport Demand Allocation Model (MADAM). In the existing conditions, it is found that there is 82 flights/day while the simulation results show 86 flights/day. There is an error of 4.9%, which means that the frequency of flights needs to be increased four times. Whereas at the APT airport. Pranoto, there is no difference between existing routes and schedules and the simulation results, which are 20 flights/day. It means that in terms of both the landside and airside, the capacity is optimum. Also, the simulation results of the movement of passengers to the APT. Pranoto Airport and SAMS. Sepinggan Airport Balikpapan shows the movement of 176 passengers from the APT. Pranoto Airport to SAMS Sepinggan Airport of Balikpapan. There are several passengers at APT. Pranoto cannot be transported according to route modeling and flight schedules due to the airport's overload capacity.*

Keywords— Airport Hub, MADAM, East Province.

I. INTRODUCTION

East Kalimantan Province is the fourth largest province in Indonesia, with an area of 127,346.92 km2. In general, topographic conditions in East Kalimantan are hilly with altitudes ranging from 0-2,500 meters above sea level. Astronomically, East Kalimantan (East Kalimantan) is located between 1130 35'31 "- 1190 12'48" East and 20 34'23 "LU - 20 44'14" LS. Based on the results of the 2010 Population Census (SP), the total population in East Kalimantan was 3,047,479 inhabitants. The projected population of East Kalimantan was 3,575,449 people, with a male population percentage of 52.44 percent in 2017. The population growth rate in East Kalimantan in 2017 was 2.12 percent per year (BPS East Kalimantan, 2019) [3].

As a province that has a hilly topography, the mode of air transportation plays an important role in connecting transportation access from one region to another. Determination of candidates for the State Capital in the Province of East Kalimantan has a very significant impact on the air transportation sector in supporting flight operations.

East Kalimantan Province has 12 airports spread across several areas, including three airport hubs, namely AM Airport. Sulaiman Sepinggan (BPN) in Balikpapan, APT. Pranoto Airport (SRI) Sei Siring in Samarinda, and Kalimarau Airport (BEJ) in Berau. BPN and SRI are located in big cities (metropolitan), namely Balikpapan, as an industrial city, and Samarinda, as the Provincial Capital, with a distance of ± 100 Km. Both towns have hinterlands that intersect, causing prospective aircraft passengers to choose which airports can fly them to their destinations (O-D).

The presence of the new capital of the country that is located between the two hub airports will increase the competition between the two airports, especially in serving the same potential routes as Jakarta, Surabaya, Makassar, and Jogjakarta. It is

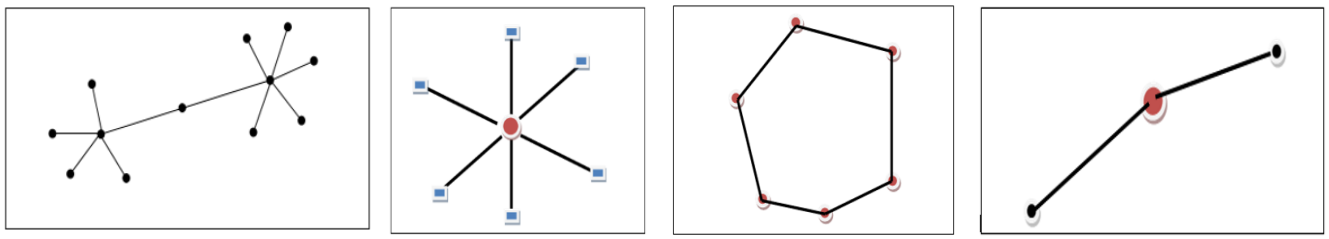
necessary to arrange the routes and flight schedules at the two hub airports using the Multiple Airport Demand Allocation Model (MADAM) to overcome the problems.

II. LITERATURE REVIEW

According to Law No. 1 of 2009, regarding Aviation, Airports are land areas and waters with certain limits that are used as airplanes to land and take off, passenger boarding and unloading, loading, and unloading of goods, and places of transfer between modes of transportation. The airport is also equipped with aviation safety and security facilities, basic facilities, and other supporting facilities. [9]

The air transportation network system consists of airport arrangements and air space for flight. Airport arrangements include of public airports and special airports. Whereas air space consists of air space above the airport, which is used directly for airport activities, air space around the airport, which is used for flight operations, and air space determined as flight path/route. (Adisamita, 2014) [2]

The determination of the form of the flight network route pattern is done to provide an efficient and effective way of the route network. The current domestic flight network is still a combination of hub and spoke patterns, grip patterns, line patterns, and combined patterns. (Adisamita, 2011) [1].



(a) **(b)** **(c)** **(d)**

FIGURE 1: Pattern of Flight network route (Adisamita, 2011)

Flight Schedule is a flight that is carried out regularly with fixed routes and schedules. Usually, guardianship is related to the allocation of existing resources over a certain period. (Pinedo, 2002) [5]

To accelerate regional / island growth through enhancing the role of the Urban/Metropolitan National Strategic Area, the Indonesian government established the Metropolitan Area through Government Regulation of the Republic of Indonesia Number 13 of 2017, concerning Amendment to Government Regulation Number 26 of 2008, concerning National Spatial Planning. The Metropolitan area is an urban area consisting of a single, independent urban area, or a core urban area with a surrounding urban area with functional interconnections. The area is linked to an integrated regional infrastructure network system, with a total population of at least 1,000,000 (one million) people. There are 13 metropolitan areas determined by the Indonesian government, one of which is the Metropolitan Area in East Kalimantan Province, which includes the Balikpapan-Tenggarong-Samarinda-Bontang Metropolitan Areas. [6]

Multi Airport System is a collection of airports that serve air traffic in a metropolitan area, two or more airports can provide services in an urban area. (De Neufville, 1995) [4].

The application of a multi-airport system has several advantages, including (1) reducing density at primary airports while increasing the capacity of regional air transportation systems. (2) Maintaining the quality of service, especially in primary airports, breaks down and reduces the effects of disruptions that may occur in airport operations. (3) Providing alternative travel options for people in the metropolis can reduce the distance and travel time to the airport. (4) Generating economic activities in the surrounding area, such as increasing employment, tax revenue, attracting new companies, and others. (5) Reducing the impact of a service monopoly which could appear at any time in a single airport system.

III. RESEARCH METHOD

Analysis of route settings and flight scheduling is done by using the Multiple Airport Demand Allocation Model (MADAM).

The research flowchart is as follows:

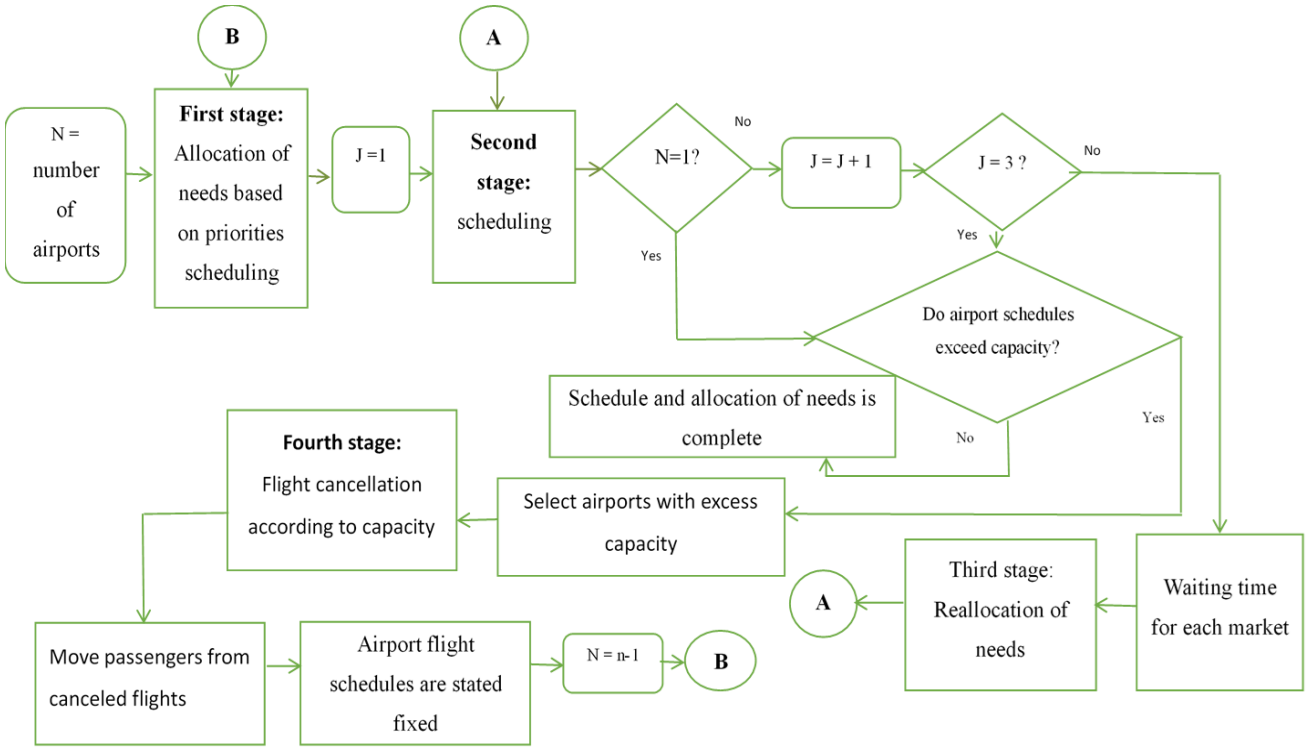


FIGURE 2: RESEARCH FLOW CHART

IV. RESULTS AND DISCUSSION

4.1 Research Data

The Province of East Kalimantan consists of 12 cities. A code is given to each region to simplify the simulation. Regions and codes in the Province of East Kalimantan can be seen in the following table:

TABLE 1
REGIONAL DIVISIONS

No	City	Code
1	Samarinda	501
2	Balikpapan	502
3	Samboja	503
4	Penajam	504
5	IKN	505
6	Tanjung Redep	506
7	Sangatta	507
8	Tenggarong	508
9	Melak	509
10	Bontang	510
11	Tanah Grogot	511
12	Wahau	512

Source: GIS data processing

Of the 13 Metropolitan Areas established by the Indonesian government, one of them is the Metropolitan Area in East Kalimantan Province, which includes the Balikpapan-Tenggarong-Samarinda-Bontang Metropolitan Area. There are two hub

airports in the metropolitan area, namely SAMS Sepinggan Airport Balikpapan and APT Pranoto Airport. To model routes and flight schedules with the concept of a multi-airport system, distance data between regions and the two Hub airports are needed.

TABLE 2
REGIONAL DIVISIONS

No	City	APT Pranoto SMD Airport (KM)	SAMS Balikpapan Airport (KM)
1	Samarinda	23.9	115
2	Balikpapan	132	11.4
3	Samboja	108	46.6
4	Penajam	183	30.7
5	IKN	151	104
6	Tanjung Redep	497	629
7	Sangatta	143	278
8	Tenggarong	52.7	139
9	Melak	348	433
10	Bontang	95	228
11	Tanah Grogot	319	203
12	Wahau	296	429

Source: GIS data processing

4.2 Flight Schedule Modeling

From flight data at the airport of APT. Pranoto Airport, researchers took data in the largest month of December 2019. The departure passengers were 32,356 people with the aircraft movements of 300 times. The number of passengers per day is 1,079 people, with the flow of planes per day is ten times.

The flight data at the airport of SAMS Sepinggan Airport Balikpapan, taken in November 2019, showed the departure passengers of 191,399 people, with the aircraft movements of 2,442 times. There were 6,380 passengers per day, with the flight movement per day of 82 times.

The data above is used in simulating flight modeling and flight schedules using the Multiple Airport Demand Allocation Model (MADAM).

Data on flight routes available at APT Pranoto Airport and SAMS Sepinggan Airport Balikpapan is needed to model flight schedules. The flight routes at the two airports are coded in the form of numbers to simplify each flight route's modeling.

TABLE 3
FLIGHT ROUTES OF APT PRANOTO AIRPORT SAMARINDA

No	Flight Route	Code
1	Jakarta (CGK)	1
2	Jakarta (HLP)	2
3	Surabaya (SUB)	3
4	Makasar (UPG)	4
5	Denpasar (DPS)	5
6	Yogyakarta (YIA)	6
7	Kalimarau Berau (BEJ)	12
8	Tanjung Selor (TJS)	17
9	Melak/Melahan (GHS)	19

Source: APT Pranoto Airport Authority

The flight routes are domestic and regularly scheduled routes. The aircraft types used are ATR72, CRJ1000, B734, B735, B738, B739, and A320.

TABLE 4
SAMS. SEPINGGAN AIRPORT BALIKPAPAN FLIGHT ROUTES

No	Flight Routes	Code
1	Jakarta (CGK)	1
2	Jakarta (HLP)	2
3	Surabaya (SUB)	3
4	Makasar (UPG)	4
5	Denpasar (DPS)	5
6	Yogyakarta (YIA)	6
7	Manado (MDC)	7
8	Semarang (SRG)	8
9	Banjarmasin (BDJ)	9
10	Tarakan (TRK)	10
11	Palangkaraya (PKY)	11
12	Kalimarau Berau (BEJ)	12
13	Pontianak (PNK)	13
14	Palu (PLW)	14
15	Banyuwangi (BWX)	15
16	Kertajati (KJT)	16
17	Tanjung Selor (TJS)	17
18	Mamuju (MJU)	18
19	Melak/Melahan (GHS)	19
20	Malinau (LNU)	20

Source: SAMS. Sepinggan Airport Balikpapan Authority

Flight frequency data obtained from airport authorities at APT. Pranoto Airport Samarinda and SAMS. Sepinggan Airport Balikpapan is as follows:

TABLE 5
FLIGHT FREQUENCY OF SAMS. SEPINGGAN AIRPORT BALIKPAPAN

No	Flight Route	Frequency
1	Jakarta (CGK)	19
2	Jakarta (HLP)	
3	Surabaya (SUB)	11
4	Makasar (UPG)	8
5	Denpasar (DPS)	1
6	Yogyakarta (YIA)	5
7	Manado (MDC)	1
8	Semarang (SRG)	1
9	Banjarmasin (BDJ)	7
10	Tarakan (TRK)	6
11	Palangkaraya (PKY)	2
12	Kalimarau Berau (BEJ)	9
13	Pontianak (PNK)	1
14	Palu (PLW)	3
15	Banyuwangi (BWX)	1
16	Kertajati (KJT)	1
17	Tanjung Selor (TJS)	1
18	Mamuju (MJU)	1
19	Melak/Melahan (GHS)	3
20	Malinau (LNU)	1

Source: SAMS. Sepinggan Airport Balikpapan Authority

TABLE 6
FLIGHT FREQUENCY OF SAMS. SEPINGGAN AIRPORT BALIKPAPAN

No	Flight Route	Frequency
1	Jakarta (CGK)	7
2	Jakarta (HLP)	
3	Surabaya (SUB)	4
4	Makasar (UPG)	1
5	Denpasar (DPS)	1
6	Yogyakarta (YIA)	3
12	Kalimarau Berau (BEJ)	2
17	Tanjung Selor (TJS)	1
19	Melak/Melahan (GHS)	1

Source: APT Pranoto Airport Authority

4.3 Modeling limits

In modeling flight schedules, it is important to consider the limits of both airports, namely the maximum number of aircraft movements per hour, flight service hours, load factors, and the departure terminal capacity.

TABLE 7
MODELING LIMITS

No	Limits	APT Pranoto Airport	SAMS Sepinggan Airport Balikpapan
1	Flight movement	7 times	10 times
2	Airport operations	15 hours	15 hours
3	Load factor	40%	40%
4	Departure terminal capacity	500 people	1405 people

Source: Secondary data & interviews

4.4 Simulation Results

Simulation results of the modeling of data and limitation criteria at APT. Pranoto Airport Samarinda and SAMS. Sepinggan Airport Balikpapan, by using the Multiple Airport Demand Allocation Model (MADAM) shows the following results:

TABLE 8
SIMULATION RESULTS OF ROUTE MODELING AND NUMBER OF FLIGHTS AT APT PRANOTO AIRPORT SAMARINDA

No	Flight Route	Flight Route	
		Existing	Simulation
1	Jakarta (CGK)	7	7
2	Jakarta (HLP)		
3	Surabaya (SUB)	4	4
4	Makasar (UPG)	1	1
5	Denpasar (DPS)	1	1
6	Yogyakarta (YIA)	3	3
12	Kalimarau Berau (BEJ)	2	2
17	Tanjung Selor (TJS)	1	1
19	Melak/Melahan (GHS)	1	1

Source: data processing

The simulation results with MADAM show no differences in the frequency of flights between the existing conditions and the simulation results of 20 flights/day. It means that in terms of both the landside and airside capacity, the capacity is optimum. The condition allows the transfer of passengers from APT Pranoto Airport Samarinda to SAMS. Sepinggan Airport Balikpapan.

TABLE 9
SIMULATION RESULTS OF ROUTE AND NUMBER OF FLIGHT MODELING AT SAMS. SEPINGGAN AIRPORT BALIKPAPAN

No	Rute Penerbangan	Flight Frequency	
		Existing	Simulation
1	Jakarta (CGK)	19	17
2	Jakarta (HLP)		2
3	Surabaya (SUB)	11	10
4	Makasar (UPG)	8	8
5	Denpasar (DPS)	1	1
6	Yogyakarta (YIA)	5	5
7	Manado (MDC)	1	1
8	Semarang (SRG)	1	1
9	Banjarmasin (BDJ)	7	7
10	Tarakan (TRK)	6	6
11	Palangkaraya (PKY)	2	2
12	Kalimarau Berau (BEJ)	9	9
13	Pontianak (PNK)	1	1
14	Palu (PLW)	3	4
15	Banyuwangi (BWX)	1	1
16	Kertajati (KJT)	1	1
17	Tanjung Selor (TJS)	1	2
18	Mamuju (MJU)	1	2
19	Melak/Melahan (GHS)	3	4
20	Malinau (LNU)	1	2

Source: data processing

The simulation results with MADAM show that there are differences in the frequency of flights between the existing conditions and the simulation results. There are 82 flights in the current circumstances. Meanwhile, the simulation results show 86 flights/day. There is an error of 4.9%, which means that there is a need to add four more frequencies.

The movement of passengers to both airports shows the combined simulation results as follows:

TABLE 10
THE RESULTS OF A SIMULATION OF PASSENGER MOVEMENTS

No	Simulation Data	Balikpapan Airport			APT Pranoto Airport		
		Fixed (people)	Move (people)	Traveling time (minute)	Tetap (people)	Berpindah (people)	Traveling time (minute)
1	Existing Data	6400	0	35.3	924	176	37.9

Source: data processing

The above table shows the movement of 176 passengers from the APT. Pranoto Airport to SAMS Sepinggan Airport Balikpapan. Several passengers in the APT. Pranoto Airport could not be transported, according to existing flight modeling and flight schedules, due to the overload capacity of the airport.

V. CONCLUSION

The research finds differences in flight frequencies between exiting conditions and simulation at SAMS airport of Sepinggan Balikpapan by using the Multiple Airport Demand Allocation Model (MADAM). In the existing conditions, it is found that there is 82 flights/day while the simulation results show 86 flights/day. There is an error of 4.9%, which means that the

frequency of flights needs to be increased four times. Whereas at the APT airport. Pranoto, there is no difference between existing routes and schedules and the simulation results, which are 20 flights/day. It means that in terms of both the landside and airside, the capacity is optimum. Also, the simulation results of the movement of passengers to the APT. Pranoto Airport and SAMS. Sepinggan Airport Balikpapan shows the movement of 176 passengers from the APT. Pranoto Airport to SAMS Sepinggan Airport of Balikpapan. There are several passengers at APT. Pranoto cannot be transported according to route modeling and flight schedules due to the airport's overload capacity.

RECOMMENDATIONS

1. Further research needs to be done by simulating a model for forecasting the number of passengers to the ultimate capacity condition by including central issues, such as the new national capital.
2. Evaluate the airport's capacity and flight schedules for route management with the concept of a multi-airport system.

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