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Runway Capacity Analysis of Flight Traffic Movement at Juanda Surabaya Airport

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Abstract: *The flight's demand for the use of runways is important to factor in planning capacity and facility requirements at airports, the growth of flight traffic at Juanda Surabaya. The airport is increasing, while the runway capacity is fixed and inadequate to serve airplane movements so that smooth flight traffic is disrupted by queues. This study aims to analyze the operational performance of runway capacity to determine the clarity between the needs and availability of runway capacity and facilities at the airport. Prediction of flight, traffic using Double Smoothing Exponential Method and comparing to the runway capacity influenced by factors increasing the airplane movement, time of runway use by airplane with a simulation of a service queue. The results showed that the current runway capacity was lower than demand so that there was a queue at the peak hour. Alternative solutions are to reduce the use of runways by airplane and rescheduled slot time for flights and developing runway capacity. It is concluded that runway capacity is lower than flight traffic movement, alternative cost optimization solutions between airlines, Perum Airnav Indonesia Juanda Surabaya branch and Angkasa Pura 1 (one) with a short-term solution that is by reducing the time of use of the runway by the plane or equalization of slot time so that the movement of the airplane does not accumulate at rush hour while for the long term with the addition of runway.*

Keywords: *Air Transportation, Flight Traffic, Runway Occupancy Tim, Plane Queuing*

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I. Introcution

Air transportation is a growing service industry for medium and long-distance travel. As a result of the implementation of the Low-Cost Carrier system with the characteristics of affordable tickets, so it has an impact on the growth of airplane movements which increased by 21% [1] from 2014 including at Juanda Surabaya International Airport. A further impact is an effect on the performance of runway capacity in anticipating the growth and smoothness of airplane movements, increased runway capacity can improve the smooth movement of traffic and flight services so that it has implications for costs and revenues both from the airside (aeronautics) and landside (non-aeronautics), as well as airline operational costs and costs for the community [2,3].

The runway is a rectangular the area on the surface of the aerodrome that the airplane uses to land or take off [4]. The runway capacity is a measure of the maximum number of airplane operations that can be accommodated by the runway in 1 hour and increased flight traffic movement is an important factor in planning capacity and facility requirements at airports [5,6]. Prediction of aviation traffic movement is needed to determine the size or dimensions of airport facilities in a macro and micro planning including environmental, economic and social issues [7].

Airport development is needed because normal capabilities have exceeded capacity. The capacity of an aerial side of an airport influences flight safety. Queuing delays occur if needs exceed the capacity of the existing capacity [6,8]. This, resulting in financial losses for flight operators, passenger inconvenience, including financial, non-financial losses and increased workload for the officers involved [3]. This research was conducted at the Juanda Surabaya Branch Surabaya Airnav Indonesia. Primary and secondary data are obtained by recording direct airplane movements, literature and documents to support analysis and discussion. Predictions of flight traffic movements use the Double Smoothing Exponential method [9].

II. Result And Discussion

Runway Capacity

Runway Capacity is a number that indicates the ability of the runway to provide airplane movement services with acceptable conditions. For planes departing, time is recorded when the airplane is permitted to start the engine (start up) until the airplane airs, while for landing airplane, it starts when the airplane touch down on the runway until the airplane is blocked on the Apron. Calculations are performed on each airplane category. Operating in Juanda International Airport with categories B, C and D. Category B is airplane when landing at speeds of 91 - 120 knots, for C the speed is 121 - 140 knots, while for category D landing speeds are 141 - 165 knots [10].

The runway capacity based on when the airplane departs and lands according to the type of airplane [5] can be calculated using the following formula:

$$Runway\ Capacity = \frac{3600\ second}{Time\ of\ Arrival/Time\ of Contingency}$$

The results of the analysis of each runway and airplane category in Table 1

Table 1. Accommodation capacity for flight Departure and Arrival

Airplane	Runway 10				Runway 28			
	Dp		Ar		Dp		Ar	
	T	C	T	C	T	C	T	C
B	310	12	185	19	380	10	185	19
C	260	**14**	175	21	260	14	175	21
D	290	12	165	22	290	12	165	**22**

Note: Dp: Departure
Ar: Arrival
T: The time the plane moves on the runway every second
C: Platform Capacity

From this data, the highest value for departure capacity is taken, 14 movements and arrivals, 22 movements. So that the runway capacity becomes 36 movements per hour because there must be a contingency in the runway capacity, then the runway capacity is reduced by contingency traffic which will be used when there is an airplane that has an emergency condition [6] for 2 movements so that the runway capacity that can be used is 34 Movement per hour.

Prediction of Flight Traffic

Based on airplane movement data at Juanda Surabaya International Airport from January 2014 to December 2018, it was analyzed using the forecasting time series method obtained by the growth of airplane movements by 120 (one hundred and twenty) months ahead. Analysis of forecasting time series data on airplane movement data using the Double Smoothing Exponential method [11] with Minitab 19 application to get the smallest prediction error value with α = 0.75. Smoothing Plot of aviating traffic movement obtained the following results:

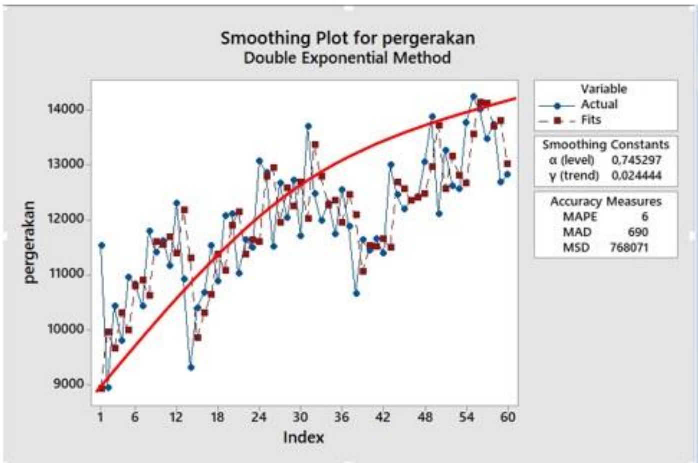

Figure 1. Smoothing plot for Flight Traffic Movement

Figure 1 above for α = 0.75 obtained the lowest Mean Absolute Percentage Error (MAPE) value of 6. Forecasting with one parameter double exponential method as follows:

$S_t' = \alpha X_t + (1-\alpha)\, S_{t-1}'$ .... (1) $b_t = \frac{\alpha}{1-\alpha}\,(S_t' - S_t'')$ .... (4)
$S_t'' = \alpha S_t' + (1-\alpha)\, S_{t-1}''$ .... (2) $F_{t+m} = a_t + b_t\, m$ .... (5)
$a_t = 2\, S_t' - S_t''$ .... (3) Where m = 1,2,3, ...

Explanation:
S_t' = single eksponensial smoothing value
S_t'' = double eksponensial smoothing value
α = exponential smoothing parameter
$a_t b_t$ = smoothing constant
F_{t+m} = forecast results for the foreseeable future periods

The results of predictions of airplane movements per hour per year using the Microsoft Excel application with supporting data of 60 samples in Table 2.

Table 2. Prediction of Annual and Hourly Airplane Movements

Year	Number of Plane Movements		Explanation
	Annual	Hourly	
2019	159945	35	To predict the number of airplane per hour rounding
2020	171366	35	
2021	182787	35	
2022	194208	36	
2023	205629	36	
2024	217050	38	
2025	228471	38	
2026	239892	38	
2027	251313	38	
2028	262734	38	

Delay

The data for 2018 for the number of hourly movements are 37 movements consisting of 17 movements that depart and 20 movements that arrive. With a ground capacity of 34 movements per hour, then with these conditions a delay will occur. To find out the delay time can be calculated with the following formula:

$$W_d = \frac{\lambda_d\,(\sigma_d^2 + \frac{1}{\mu_d^2})}{2\,(1 - \frac{\lambda_d}{\mu_d})}$$

Where:
w_d = average delay for departure
λ_d = average departure / arrival rate
μ_d = service time of departure or maximum runway capacity / runway capacity
σ_d = standar deviasi service time departure

In this formula, it can be seen the average delay result for the departing airplane is 1 minute. The data is only for airplane that will use the runway to leave, excluding the calculation of delay taxi, or delay start / Pushback. As for the incoming planes there was a delay of about 1, 2 minutes.

Reduction of Runway Occupancy Time (ROT)

The ROT calculation is obtained from a survey of the movements of planes that depart and arrive for 7 consecutive days at peak hours. The average movement during peak hours is 32 movements per hour. ROT is divided into the time for departing airplane and the time for incoming airplane. ROT is influenced by the speed of the airplane so that each airplane with different categories has different ROT values. For runway 10, the average ROT for success is 123 seconds and for arrival ROT is 63 seconds, while runway 28, the average ROT for departure is 117 seconds and for arrival ROT is 60 seconds.

Furthermore ROT data with the largest value is used to calculate the runway capacity. For foundation 10 use a value of 123 seconds and for foundation 28 use a value of 117 seconds. In accordance with the calculation of runway capacity, the obtained value of capacity for runway 10 is 29 hourly movements and for runway 28 is 31 hourly movements while must serve up to 32 hourly movements. Therefore there is a delay or movement of flight traffic becomes not smooth.

Based on prediction data for peak hours in year 2020 to 2023, flight movements can reach 36 movements per hour. Perum Airnav Branch Juanda Surabaya has set the ROT to be 100 seconds [12]. With these assumptions, it is necessary to increase the runway capacity by reducing ROT in Table 3.

Table 3. Reduction in ROT

Airplane Movement	Contingency	Runway Capacity	Airplane Detection ROT
36	2	34	100
38	2	36	95

The reduction in ROT time has been maximized, this is because there are rules that only allow an increase in runway capacity for airports that have one runway by 5% by reducing ROT. Based on prediction data for hourly movements at peak hours and the amount of capacity that has increased to 36, the addition is only effective until the time of 2023. Because for 2024 onwards, the runway capacity is no longer sufficient to serve airplane movements.

Rapid Exit Taxiway (RET)

RET is closely related to arrival ROT, where the location or number of RET depends on the arrival ROT value. Based on observations obtained data in Table 4.

Table 4. MROTL Runways 10 and 28

Exit Taxiway	Runway	Number of planes	%	MROTL (second)
N3	10	3	20	61,3
N6		1	6,7	62
N5		9	60	54
N7		-	-	-
S3		1	6,7	53
S4		1	6,7	41
S2		-	-	-
S5		-	-	-
N1	28	-	-	-
N2		8	53,3	54,5
N3		1	6,7	45
S1		-	-	-
S2		4	26,7	60,8
S3		-	-	-
S4		-	-	-

The most common use of RET for runway 10 uses N5 on average takes 54 seconds to leave the runway. So the time needed to leave the runway via N5 is smaller than the ROTL set by Juanda airport, which is 60 seconds. Whereas the use of RET for runway 28 uses the most N2 on average takes 54.5 seconds to leave the runway. So the time needed to leave the runway via N5 is smaller than the ROTL set by Juanda airport, which is 60 seconds. Based on data from the use of RET using the 10 and 28 runways it is still sufficient to serve airplane movements during peak hours. So that the addition of RET is not needed to be able to increase runway capacity.

Alternative Addition Runway

The capacity of airports, especially Juanda Airport, is very limited when compared to the demand for airlines as described above that the capacity of airports which only 34 movements per hour must accommodate 37 movements per hour in 2018 and is expected to reach 38 movements in 2028.

Figure 2. Area Plan for Adding Runway [13]

According to the picture above, the plan to add a runway must be done east of the existing airport, because the area is a pond area that is no longer in use and is not a conservation area with a reclamation plan.

The current condition of Juanda Surabaya Airport with one runway has a capacity of 34 movements so Juanda Surabaya Airport needs to add the runway as seen in the picture above with a separation distance of 1300 meters whose maximum movement is 99 movements per hour [6].

III. Conclusion And Recommedation

Conclusion

The operational performance of the runway capacity is lower than flight demand so that there is a holding of airplanes, especially at rush hour ie 18.00 - 19.00.

An alternative solution is to optimize costs between Airlines and Airport providers, a short-term solution by minimizing ROT with a view to reducing the time needed for the airplane to use the runway so that the costs incurred by airlines can be optimized. The addition of runway capacity by minimizing ROT has limitations, a maximum capacity of 5%. Next is to equalize the schedule so as not to accumulate during rush hour, will be moved to other hours with sufficient capacity. This will have an impact on airline revenues, so if the schedule is changed it will have a decrease in demand. The long-term alternative is to add a runway but the flight cost for the airport service provider. The addition of the runway can reduce airline expenses and the cost of the community or passengers caused if there is a queuing of flight movements.

IV. Recommendation

Development of Juanda International Airport, Surabaya. Faster Platform Development is needed in the short term to reduce the impact of stakeholders' costs. ATC and pilot collaboration is needed to optimize ROT especially to immediately leave the runway. Planning to increase the runway capacity begins with funding sources that can be obtained from the Government and Business Entity Cooperation Scheme (GBECS) or with foreign loans and then land plans or reclamation areas that will be built to increase the runway.

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