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An Analysis of Runway Capacity at International Airport Sultan Aji Sulaiman Balikpapan in East Kalimantan-Indonesia

Jamaluddin Rahim
Lecture of Civil Aviation Safety and Engineering Academy of Makassar, Indonesia

Abstract:- International Airport Sultan Aji Sulaiman Balikpapan in East Kalimantan growth of aircraft movements during the last 5 years at 12.20%. This growth impact on air traffic services in the future given the runway which includes the single runway operation supported 5 exit taxiways, so the runway capacity is limited. This study aims to find the concept of increasing the capacity of the runway through the analysis method runway occupancy time landing (ROTL), runway occupancy time of take off (ROTT) and exit taxiway configuration. The results indicate that the runway capacity can be increased from 21 to 28 aircraft movements of aircraft movement through the reconstruction of exit taxiway Delta into Rapid exit taxiway Delta.

Keywords:- Runway, capacity, exit taxiway and configuration

I. INTRODUCTION

National air traffic growth over the last 5 years show the fantastic figures, growth in domestic air transport flight frequency reaches 18%, which connect 107 cities across Indonesia on 217 routes served by 18 airlines.

The number of domestic passengers carried rose 16% from a year earlier, the company of Lion Air flights provides distribution by 40%, Indonesian Garuda 22%, the next Sriwijaya Air 12%, the remaining 24% is distributed on 15 operators. This distribution is expected to shift in the coming years given the emergence of several new operators with a level of service that is quite promising.

Flight operational services is closely associated with the presence of airports in Indonesia, from 298 airports under the Minister of Communications No. 69 of 2013 on there Airport Affairs Order 228 that serve flight operations or 76.51%, and is expected in the next few years is expected to increase by the operation of some of the new airport.

Airport services which showed a high level of activity is an airport which is managed by PT. (Persero) Angkasa Pura I and II to manage 24 airports Air mostly serves as a hub and serves 88% of domestic passengers and 100% of international passengers, while airports which is managed by the Airport Management Unit of the Directorate General of Civil Aviation consists of 148 airports grade I to grade III serves domestic flights with passengers distribution rate of 12%.

International Airport Sultan Aji Sulaiman Balikpapan in East Kalimantan, including airports are managed by PT (Persero) Angkasa Pura I, the growth rate of air movement over the last 5 years at 12.20%. This growth will have an impact on air traffic services in the future in view of the runway which includes the single runway operation supported 5 exit taxiways, so the runway capacity is limited. This study aims to find a concept to increase the capacity of the runway via exit taxiway configuration.

II. LITERATURE REVIEW

Taxiway A defined path on a land aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another" **Horonjeftf (1975),** The principal function of taxiway is provide access from runways to terminal and service hangers. Taxiways should be arranged so that aircraft which have just landed do not interfere with aircraft taxiing to take off. At busy airports where taxiing traffic is expected to move simultaneously in both directions, parallel one – way taxiways should be provided. Route should be seleccted which will result in shortest practicale distances from terminal area to the ends of runways used for take off. Again, at busy airport taxiways should be located at varios points along runways, so landing aircraft can leave the runways as quickly as ossible to clear them for use by aircraft [4].

Aerodrome Design Manual, (2005) In planning the general lay out the taxi way system, the following principles should be conciderend :

a. Taxiway routes should connect the varios aerodrome elements by the shorted distances, the minimixing both taxiing time and cost

b. Taxiway routes should be as simple as possible in order to avoid pilot confucion and the need for complicated instruction
c. Straight runs of pavement should be used wherever possible, where changes in direction are necessary, curves of adequate radii, as well as fillet or extra taxiway width, should be previded to permit taxiing at the maximum practical speed
d. Taxiiwing crossings of runways and other taxi way should be avoided whenever possible in the intrests on safety and reduce the potensial for significant taxiing delay
e. Taxiing routings should have as many one way segments as possible minimize aircraft conflicts and delay. Taxiways segmen flows should analysed for each configuration under which runway(s) will be used [1]

Aerodrome Design Manual (2005) Rapid exit taxiway. A taxiway connected to a runway at an acute angle and designed to allow landing aeroplanes to turn off at higher speeds than are achieved on other exit taxiways there by minimizing runway occupancy times**.**

A decision to design and construct a rapid taxiway is based upon analyses of existing comteplated traffic. The main purpose of these taxiway is to minimize aircraft runway occupancy and thus increase aerodrome capacity. When the design peak hour traffic density approximately less than 25 operation (landing and take off) the right angle exit taxiway may surffice. The construction of this right angle exit taxiway is less expensive, and when properly located along the runway, achieves an efficien flow of traffic. [1]

The extablishment of single worldwire standard for the design of rapid exit taxiways has many obvious advantages. Pilot become familiar with the configuration an can expect the same result when landing at any aerodrome with thelse facilities. Accordingly, design parameters have been extabilished in Annex 14, Volume 1 for grouping exit taxiways associated with a runway whose code number 1 or 2 another grouping for code 3 or 4. [1]

Since the introducting of rapid exit taxiway, additional field tests and studies have been conducted to determine taxiway utilization, exit taxiway location and design, and runway occupancy time. Evaluation of such material taxiway location and design criteria based on specifield aircraft populations maving at relatively high speeds.

The is come difference of opinion with respect to the speed at which pilots negotiate rapid exit taxiways. While it has been inferred from some studies that these taxiways are normally used at a speed not higher than 46 km/h (25 kt) and even in some cases at lower speeds whwn poor breaing action or strong cross wind encomtered, measurement at other aerodrome have shown that they are being used at speeds of over 92 km/h (49 kt) under dry conditions. For safety reason 93 km/h (50kt) has been taken as reference for determining curve radii abd adjacent straight partion for raoid exit taxiways whwre the code number 3 or 4. For computing the optimum exit location along the runway, however, the planner will choose alower speed. In Case the optimum utilization of rapid exit required pilot cooperation instruction on the design of, benefit to obtained from use of, these taxiways may increase their use. [1]

For the purpose of exit taxiway design, the aircraft are assumed to the cross the treshold at an average 1,3 times the stall speed in the landing mass with an average gross landing mass of about 85 percent of maximum. Futher aircraft cab be grouped on the basis of their threshold speed at sea level as follows :
Group A - less than 109 km/h (91 kt)
Group B - between 169 km/h (91 kt) and 259 km/h (140 kt)
Group C - between 224 km/h (121 kt) and 259 km/h (140 kt)
Group D - between 261 km/h (141 kt) and 306 km/h (165 kt), although the maximum threshold crossing speed air craft curretly in production is 282 km/h (152kt). [1]
An analysis of same aircraft indicated that they may be placed in the groups as follows :
Group A - DC3, DHC6, DHC7
Group B - AVRO RJ 100, DC6,DC7, Fokker27,28, HS146,748, IL76
Group C - A300, A310, A320, A330, B707, B727, B737, B747, B757, B767, DC8, DC9, MD89, MD90, DC10, L1011
Group D - A340, B747, B777, DC8,DC10, MD11, IL 62, Il 86, IL 96, L 1011
Annex 14 Aerodrome (1994), ”Taxiways linked to runways at an angle that permits aircraft to exit the runway at high speeds (40–58 mph or 65–93 km/h). The intersection angle of such taxiways should not be less than 25° nor greater than 45°. Ideally, it should be 30°.”

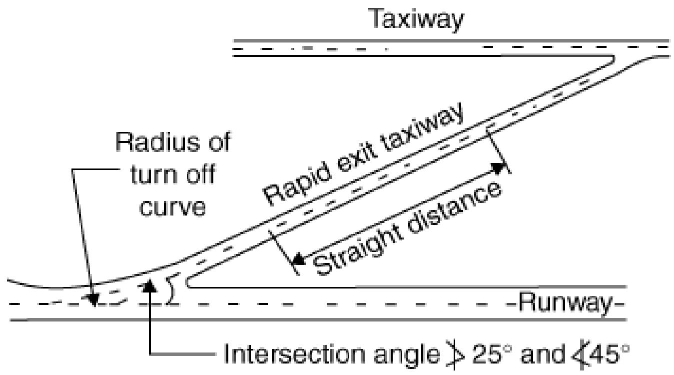


Figure 1. Rapid Exit Taxiway

Accumulation using rapid exit compared to the distance from the threshold set out in Table 1 of this means that when a rapid exit taxiway located at a distance of 2200m from the threshold, 95 percent of aircraft in group A could exit through the taxiway. In the same way, the rapid exit taxiway located at 2300m, 2670m and 2950m from the threshold could be used by 95 percent of the planes in groups B, C, and D, respectively. [2]

Table 1. Accumulated Rapid Exit Usage by Distance From Threshold (Metres)

Arcraft category	50%	60%	70%	80%	90%	95%	100%
A	1.170	1.320	1.440	1.600	1.950	2.200	2.900
B	1.370	1.480	1.590	1.770	2.070	2.300	3.000
C	1.740	1.860	1.970	2.150	2.340	2.670	3.100
D	2.040	2.190	2.290	2.480	2.750	2.950	4.000

According to Indonesia Slot Coordinator, runway capacity is the number of aircraft operations (take-off and landing) for a certain period. Runway capacity at each airport is different and depends on:

1. Aerodrome/runway lay out,
2. Facility of paralel taxiway, number of exit high speed taxiway (rapid exit taxiway),
3. Facility of aviation navigation and communication.
4. The separation policy between the aircraft (in Indonesia 6 NM between *arrival & arrival*, 8 NM between *departure & arrival*,) - in USA 3,125 NM/5 km).
5. Type mixed of aircraft (all jet operation or aircraft).

Declare runway capacity is arranged in the DOC.9426 (ATS Planning Manual "Appendix C Techniques for ATC Sector/Position Capacity Estimation"), "an ATC unit can not operate at full capacity throughout the whole operating shift, since there are several variables that significantly reduce capacity at certain times. Therefore,it is advisable to adopt percentages between 80% and 90%,thus giving more flexibility to capacity values, that is, an ideal interval that preserves the safety of air operations".[3]

$$\text{Runway Capacity} = \frac{3600\ \text{seconds}}{\text{TA} + \text{TD} + \text{C}}$$

Explanation:

- Time of Arrival (TA) is start from cross beginning of runway in use untilclear of the runway
- Time of Departure (TD) is start from entering runway in use untilcrossing endof runway or start turning
- Contingency (C) is toleransi jarak/waktu pengaturan antara traffic (arrival and departure) 8 nm between departure and arrival, 6 nm between (arrival and arrival).

For comparison the data capacity of the runway at some airports in Indonesia showed separation-departure departure for 120 seconds, the departure-arrival (8 NM) for 203 seconds, and the arrival-arrival (7 NM) for 178 seconds; so as to achieve 100% of the runway capacity by 22 traffic and runway capacity as much as 18 to 80% of traffic, with Runway Occupancy Time of Take-off (Rott) for 100 seconds and Runway Occupancy Time Landing (ROTL) for 90 seconds.

III. RESULT AND DISCUSSION

1. Aircraft of movement

The method is conducted to analyze the capacity of the runway is calculating landing runway occupancy time (ROTL), runway occupancy time of take off (ROTT) and exit taxiway Delta configuration.

The number of aircraft movements during the period of last five years has seen this growth in 2009 amounted to 49 946 movements, increased to 56 575 in 2010 or there is a growth of 13.3%, then in 2011 increased to 62 955 movements or increased by 11.28 % whereas in 2012 to 72 882 movement or growth of 15.8%; whereas in 2013 amounted to 79 019 movements or grew by 8.4%, so the average growth over the five years of 12.2%. To detail can be seen in Figure2.

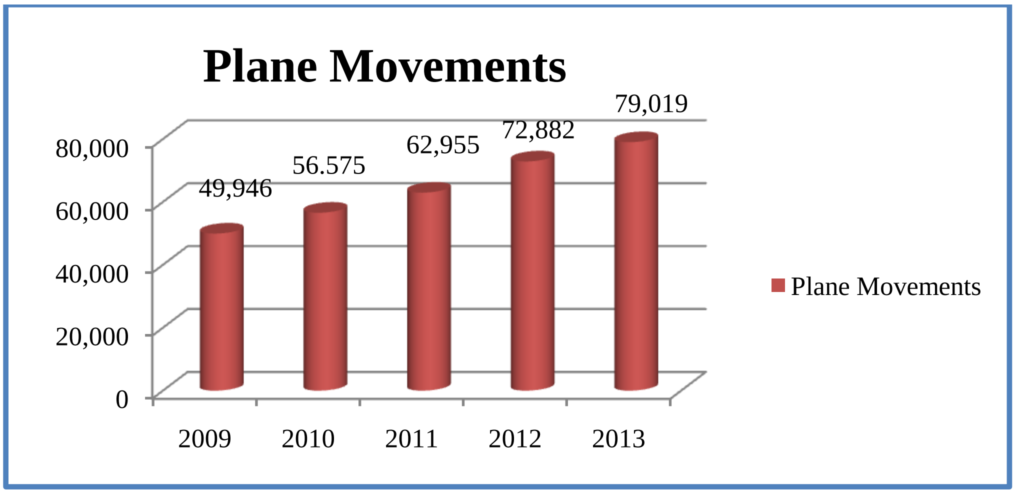


Figure 2. The number of aircraft movements in 2009 To In 2013

The growth of aircraft movements during the past five years and is expected to remain the case would have an impact on the capacity of the runway during the peak hours. Aerodrome manager has done Notice to Airport Capacity (NAC. In Doc 9426 part II Air Ttaffic Servise (ATS) Planning Manual Appendix C Techniques for ATC Sector/Position Capacity Estimation, mentioned that "an ATC unit can not operate at full capacity throughout the whole operating shift, since there are several variables that significantly reduce capacity at certain times. Therefore, it is advisable to adopt percentages between 80% and 90%, thus giving more flexibility to capacity values, that is, an ideal interval that preserves the safety of air operations.

In the Standard Operation Procedure (SOP), separation agreed to provide air traffic services are:

1. DEP – DEP. Separation between Departure: for all aircraft is 2 seconds or 120 seconds
2. DEP – ARR. Separation between Departure with the Arrival. More familiar to the Release Clerance is 7 NM. The conversion to second is 159 seconds
3. ARR – ARR. Separation between Arrival is 7 NM. The conversion to the second is 159 seconds

maximum runway capacity (100%) is 26 movements. So that, Sultan Aji Sulaiman International Airport runway capacity declared (80%)dari maximum runway capacity(100%) i.e.:

80 % x 26 = 20,8 = 21 or if it uses a formula :

Runway capacity is obtained 21 movements.

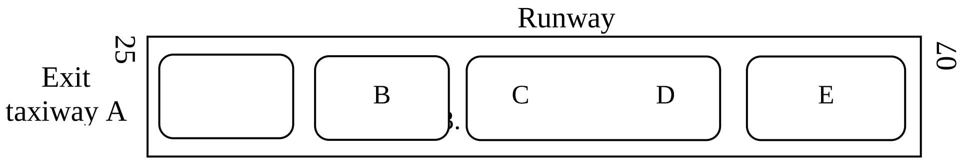
2. Runway In Use (RIU)

International Airport Sultan Aji Sulaiman Balikpapan has taxiway Alpha (A), Bravo (B), Charlie) C, Delta (D), Echo and NP, uses runway 07 and runway 25, both during take off and landing aircraft depending on wind conditions , but the intensity of the use of runway 25 is much higher, reaching 71.40%, this was due to be supported by the facility of the Instrument Landing System (ILS), as shown in table 2.

Table 2. Runway in Use Tahun 2013

No.	Month	RWY(%)		Helipad	Total(%)
		07	25		
1	January	24,1	66,9	9	100
2	February	38,5	49,5	12	100
3	March	32,3	57,8	9,9	100
4	April	23,6	66,4	10	100
5	May	18,5	70,2	11,3	100
6	June	17	72,1	10,9	100
7	July	5,2	83	11,8	100
8	Augustus	2,4	87,8	9,7	100
9	September	0,7	89,3	10	100
10	October	5,9	82,7	11,4	100
11	Nopember	24,5	64,5	11,1	100
12	December	24,1	66,9	9	100
Average		18,1	71,9	10.5	100

Landing aircraft using the runway 25, will be more out via taxiway D. While the taxiway D has a configuration perpendicular to the runway that makes an angle of 90o to the runway so it takes a long time to carry out or maneuver deflection of the runway. The impact of these events resulted in a delay to the aircraft that will take off and landing. As in Fig. 3.



Based on observations during peak hours the number of aircraft movements at 25 fixed wing and rotary wing 3. This condition indicates that the amount of movement during peak hours has exceeded the maximum capacity that can be accommodated by the runway. One contributing factor is that such a configuration taxiway exit taxiway perpendicular to the runway. In fact, every plane that landed on a runway is expected to come out of the runway as soon as possible. However, the existing taxiway configuration has not been able to minimize the time the use of the runway or runway Occupancy Time (ROT).

3. Runway Occupancy Time Landing (ROTL)

Based on the value of recording Runway Occupancy Time Landing (ROTL) showed that although the same type of aircraft, but the value can be different ROTL. To compare the effectiveness of aircraft movements out of the runway via a taxiway exit particular, should pay attention to two or more similar aircraft such as the B735, RIU 25 at exit taxiway Echo and Delta with a 90 and 57 second or 33 seconds there is a difference, the difference in the length of time use by aircraft to leave the runway is affected by wind direction and speed, weather conditions, and the weight of air cargo.

In addition there ATR san B735 aircraft types that use the exit taxiway Delta with a 51 and 59 seconds, while the exit taxiway echo the type of aircraft CJRX, B735 and B738 with time 67,50,70 and 90 seconds, so that the average time required for the exit as shown in Table 3, are:

$$\frac{(67 + 50 + 70 + 90)}{4} = 69{,}25 \rightarrow 70\ s$$

Table 3. Runway occupancy time landing (rotl)

No.	Type of Aricraft	Rotl	Riu	Exit taxiway
1	B739	85 S	07	ALPHA
2	ATR7	53 S	07	BRAVO
3	ATR72	48 S	07	CHARLIE
4	AT42	62S	07	CHARLIE
5	A320	59 S	07	BRAVO
6	B739	77 S	07	ALPHA
7	CRIX	67 S	25	ECHO
8	ATR7	51 S	25	DELTA
9	CRJX	50 S	25	ECHO
10	AT42	47 S	25	CHARLIE
11	B738	70 S	25	ECHO
12	B735	90 S	25	ECHO
13	B735	57 S	25	DELTA

Other information indicates that two CRJ aircraft types, but each takes 67 and 50 seconds to exit taxiways, resulting in differences in 17 seconds, which means that one can actually use the aircraft CRJX exit taxiway Delta, but because of the configuration of the exit taxiway Delta perpendicular to runway so that had difficulty rolling consequently performed at low speed.

Landing aircraft using the runway 25, and exit taxiway D, with D taxiway configuration as right angle taxiway taxiways that are perpendicular to the runway will take time to do the deflection out of the runway, so the landing aircraft, can not get out of the runway at a speed that high enough so that the runway could not be cleared faster.

If done calculates the average speed of the aircraft with various types by comparing the distance threshold with exit taxiway Echo length of 2,500m with ROTL, the aircraft speed is 27.78 m/sec, 75.71 m/sec, 50 m/sec and 37.31 m/sec, or an average of 47.7 m/sec or 171.72 km/h while the distance from the threshold with exit taxiway Delta is 1,890 m, so that the air speed is 37.06 m/sec and 33.16 m/sec or an average of 35.11 m/sec or 126.40 km/h.

Based on the results of these calculations show that the type of aircraft C can exit at exit taxiway Delta because of the speed of the aircraft occurred on the runway is still lower with the specified standards are 171,72km/h less than 224-259 km/h, whereas if it is associated with a standard the percentage of aircraft capable of exit at a distance of 1.890m and 2.500m from the threshold seen that aircraft type C only capable of 70% on exit taxiway D and 90% of the exit taxiway Echo, considering the types of aircraft operating at the airport are not all included in the category C so that all types of aircraft can exit at exit taxiway Echo.

4. Runway Occupancy Time Take off (ROTT)

The time needed each aircraft during take off by the sample is 31 seconds and a maximum of at least 112 seconds, or an average of 51.42 seconds, the amount of time greatly influenced by the type of aircraft, the maximun take off wight and manuevre for aircraft during take off. This time also the effect on the next plane movement both for landing and take off. The faster the aircraft clear of the runway will be the greater of aircraft capacity of each runway. The value of time gives meaning that the time required is less than that recommended that departure - departure 120s and departure - arrival is 159 seconds as shown in Table 4.

Table 4. Runway occupancu time take off

No.	Type of Aricraft	Rott	Riu	Started Taxiway
1	B735	46 S	07	ECHO
2	A370	31 S	07	ECHO
3	AT45	41 S	07	DELTA
4	B739	38 S	07	ECHO
5	DHC6	43 S	07	DELTA
6	AT42	112 S	07	DELTA

7	B739	68 S	25	ALPHA
8	B738	35 S	25	ALPHA
9	D328	50 S	25	ALPHA
10	B739	55 S	25	ALPHA
11	B739	43 S	25	ALPHA
12	B739	55 S	25	ALPHA

5. Runway Capacity

One method that can be done to increase runway capacity is far Occupancu Time Landing Runway (ROTL) or Runway Occupancu Time Take off (Rott), so that the configuration becomes rapid exit taxiway exit taxiway will be able to reduce ROTL on any type of aircraft, so that kind of aircraft on certain conditions for this exit to exit the taxi Echo can be done on exit Txiway Delta.

If the exit taxiway Delta, located at a distance of 1890 meters from the threshold of runway 25, reconfigured into a rapid exit taxiways, aircraft 80 percent in group B (speed between 169 - 259km/h), 70 percent of the planes in group C (speed between 224 - 259km/h), and so can exit through the taxiway. Thus, aircraft Category B, C, and D are operating (C208, ATR72, MA60, B734, B738, A320, A330, LJ35 and others) can minimize ROTL that increase runway capacity can be achieved.

Exit taxiway configuration currently lacking support smooth air traffic control, particularly its effect on runway capacity. Therefore, it is proper reconfiguration is done in particular taxiway taxiway D is most often used as exit taxiways on runway 25. Therefore, the existence of rapid exit taxiways will be able to minimize ROTL required for landing aircraft. So that runway capacity can be increased, as shown in figure 4.

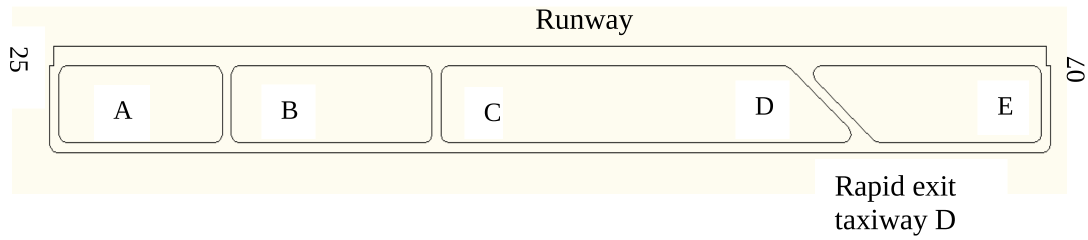


Figure 4. Configuration rapid exit taxiway D

The analysis showed that the landing aircraft using the runway 25, can quickly clear of the runway so that the time of use by aircraft landing runway can be minimized, nor plane will take off did not require a longer time to get clearance from Air Traffic Controller. If the formula used to establish ROTL runway capacity by 90 seconds and 100 seconds Rott arrival and departure 191 seconds, then the runway capasity based formula will get 28 aircraft movements. That is the runway capacity can be increased from 21 to 28 water craft movement of water craft movement.

IV. CONCLUSIONS

To increase the capacity of the runway reconfiguration can be done through an exit taxiway Delta ie increase runway capacity from 21 to 28 water craft movement of water craft movement. Recommended for short-term programs can be done reconfiguration rapid exit taxiway Delta into a taxiway.

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