



Analysis of Saturated Capacity on the Runway Based on Advisory Circular 150/5060-5 As a Study Material for Airport Management Learning

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Abstract: The demand for air transportation from year to year until 2018 continues to increase. However, in 2019 it decreased as a result of the increase in air ticket fares, as well as in 2020 as a result of the COVID-19 pandemic. Although demand is experiencing a decline, knowing airport capacity is important in airport planning, which is one of the disciplines studied in airport management. Therefore, this research aims to estimate the saturation capacity of the runway at Sultan Mahmud Badaruddin International Airport (SMB) II, using the method developed by the Federal Aviation Administration (FAA) and specified in the Advisory Circular 150/5060-5. The results of this study can be used as study material in learning the field of airport management science. Based on the data obtained and processed, the results show that the saturation capacity of the runway per hour for runway 11 directions is 53 for Visual Flight Rules (VFR) and 49 Instrument Flight Rules (IFR). Meanwhile, the direction of runway 29 is 50 in VFR conditions and 46 in IFR conditions. So that the average saturation capacity for both runway directions is 51 in VFR conditions and 48 in IFR conditions. This runway capacity calculation method cannot accommodate differences in the flight separation rules applied, so that this capacity will be achieved if Atnav Indonesia, Palembang Branch as the manager of flight navigation services at SMB II Airport applies the same rules as the FAA. The currently applied separation rules are relatively larger than those set by the International Civil Aviation Organization (ICAO) and also the FAA. As an ICAO member country, it is still possible to lower the separation rules set by ICAO to increase runway capacity. The conclusions of the research have been obtained from the analysis of the saturated capacity of the runway based on the advisory circular 150/5060-5 which has been used as a study material for learning in the field of airport management science.

Keywords: airport management, learning resources, runway capacity

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INTRODUCTION

The rapid development of air transportation can be seen from the increasing number of airplane passengers. The number of passengers carried by national airlines from 2009 to 2018 continued to increase, both domestic and international passengers. In 2009 the total number of passengers transported was 48,566,641 people, in 2010 with a total of 55,653,110 people, in 2011 with a total of 67,827,179 people and so on until 2018 with a total of 115,661,544 people (INACA, 2019). Since the last decade, the number of air transport passengers has continued to increase by around 15% per year (Sefrus et al., 2017). During the period time until 2019 the number of passengers continues to increase (Sukriawati et al., 2016; Young, 2021).

An increase in the number of requests for air transportation will have an impact on flight safety, especially if the aircraft operating exceeds the airport's capacity. Problems will arise when airport capacity, especially airside (runway) cannot serve this request (Safrillah & Putra, 2017). The complexity of the runway is a bottleneck at the airport, so knowing its capacity is very important (Sampurno et al., 2017). The increasing demand for air transportation, both in terms of the number of passengers, goods and aircraft movements, will have a direct impact on the airport's capacity (Fatchiyah, 2017). Estimating capacity is the most important issue in all airport planning and analyzing the capacity effect of specific operational techniques on a particular scenario, will help evaluate its potential application (Diaz et al., 2019). The expansion of airport capacity must be modeled and assumptions made about the effect of capacity on demand, competition between airlines, aircraft types, fares and other characteristics at the airport (Dray, 2020).

The COVID-19 epidemic is having a significant impact on the aviation sector. The aviation industry was already impacted the hardest by the COVID-19 pandemic, and its future is uncertain (Melas & Melasova, 2020; Dray & Schafer, 2021). In the five airports studied, it was established that the number of goods loaded and aircraft passengers decreased in 2020 compared to 2019, both for domestic and international flights. Even if the COVID-19 pandemic is difficult, particularly for the aviation business, you must stay strong and be

able to conquer it to the best of your ability, as well as adopt health protocols (Sugiarti, 2021). Sultan Mahmud Badaruddin Airport (SMB) II is an airport serving the city of Palembang, South Sumatra and its surroundings. The airport is located in KM. 10 Sukarama District. Has a runway with a length of 3000 meters, a width of 45 meters, with runway numbers 29 and 11. No information has been obtained about the amount of runway capacity it has. Runway capacity in airport planning is defined in two ways, namely (Horonjeff et al., 2010; Neufville & Odoni, 2013; Young & Wells, 2011) explains (a) saturated capacity which can be interpreted as an estimate of the number of aircraft movements that can be accommodated by a runway system in a certain period, under conditions of continuous demand regardless of the delay that occurs, without violating the rules of Air Traffic Management, and (b) practical capacity which can be interpreted as an estimate of the number of aircraft movements that can be accommodated by a runway system in a certain period, taking into account the tolerable delay, which is not more than 4 minutes. Based on the rule of thumb, the practical capacity of the runway is approximately equal to 80% to 90% of the saturated capacity of a runway system.

The research conducted aims to estimate the runway capacity of SMB II Airport and analyze what factors affect runway capacity as study material in learning in the field of airport management studies. Learning materials are summaries of material given and taught to students in the form of printed materials or in other forms stored in electronic files, both verbal and written (Aisyah et al., 2020). Learning resources are all sources used by students in learning, namely educators, learning materials, environment, methods, and media (Samsinar, 2019). Airport management can be interpreted as managing, managing and managing airports (Gesit et al., 2019). The results of this study, in addition to being used as a basis for planning airports in the future, can also be used as a source of learning in the field of airport management, considering that studies in the field of airport management are still very minimal.

METHODS

Data collection is an activity carried out to reveal various phenomena, information or conditions of the research location (Maulida, 2020). Data collection methods used are interviews, observation and literature review, to obtain the necessary data. The data collected in the form of primary data and secondary data. Primary data is data obtained directly from the object of research, while secondary data is data obtained indirectly from the object of research (Pratiwi, 2017). The primary data in this study were obtained from SMB II Airport and Airnav Indonesia Palembang Branch, while secondary data was obtained through websites or journals. The data collected includes: Air Transport Data for the last 3 years (2018-2020); Runway and Exit Taxiway Configuration; Aeronautical Information Publication; Standard Operating Procedures for Air Traffic Management; and Data on maximum take-off weight. In 1960 the Federal Aviation Administration (FAA) contracted with the Airborne Instruments Laboratory to develop a mathematical model for estimating runway capacity. Furthermore, the determination of the runway capacity per hour is made using a computer program developed specifically for this purpose. Based on the computer program, the FAA developed the Airport Capacity Handbook as contained in the Advisory Circular (AC) 150/5060-5. Data processing in this study, was carried out using AC 150/5060-5 (Horonjeff et al., 2010) which is as follows.

The number and layout of the runways, as well as their use for arrivals only, departures only or mixed are the main variables in the calculation of runway capacity. In AC 150/5060-5, there are around 64 runway configurations that are used as the basis for calculating runway capacity. Each configuration has a different capacity with respect to the safe separation between departing and landing aircraft (FAA, 1983). Weather phenomena that affect flight operations, especially at airports, are ceiling (cloud height) and visibility (distance of view). There are 3 categories for this condition, namely (FAA, 1983) Visual Flight Rules (VFR), cloud height above 1000 ft and visibility over 3 miles. Instrument Flight Rules (IFR), cloud height 670 to 1000 ft and/or visibility 1 to 3 miles. Poor Visibility Condition (PVC) or weather conditions below the minimum, where the cloud height is below 670 ft and or visibility is less than 1 mile.

On the fact that the aircraft separation rules are different in VFR and IFR conditions, what is first needed is to determine the conditions of cloud height and visibility, or more precisely, the separation rules that apply to flight conditions when the cloud height is at least 1000 ft and the closest visibility is 3 miles. This condition produces a VFR condition. If one or both of these conditions are not met, then IFR conditions apply. Of course, all airports have a period of time during which IFR conditions apply. Therefore, the runway capacity per hour is generally determined for each of these conditions (Horonjeff et al., 2010). Mix Index is a mathematical function used in calculating runway capacity to determine the level of influence of wide-body aircraft on the runway system. This is related to the difference in the speed of the aircraft when approaching (approach) so that the time required is different for each class of aircraft, in addition to the effect of air rotating behind the aircraft engine (wake turbulence), especially when operating behind a wide body aircraft so there must be some distance. safe between planes. The greater the difference in the class of aircraft

operating, the greater the safety distance required and means less operating capacity generated (Horonjeff et al., 2010). In this case the aircraft are classified as follows:

Table 1. Aircraft Classification

Airplane Class	Maximum Take Off Weight (pounds)	Number of Machines	Turbulence Class
A	< 12,500	Single	Small(S)
B	< 12,500	Plural	
C	12,500 - 300,000	Plural	Medium/Large(L)
D	> 300,000	Plural	Width/Heavy(H)

Source: (FAA, 1983)

After classifying the aircraft using the table above, then the Mix Index is calculated using the following formula (FAA, 1983). Mix Index from the addition the percentage of type C aircraft that use the runway to the percentage of type D aircraft that use the runway. Percent Arrival is the ratio of the number of landings to all aircraft operations, using the provisions of the FAA (1983). The greater the percentage of arrivals, the smaller the resulting capacity. This is because the arrival procedure requires a longer time than the aircraft departure or takeoff procedure in terms of separation or safe separation that must be provided to the aircraft. Touch and Go is an aircraft operation that only touches the runway without stopping. Percent Touch and Go is the ratio between the number of Touch and Go with the entire operation of the aircraft, which is calculated referring to the (FAA, 1983).

Exit factor is a factor caused by the number of exit taxiways and the distance of the exit taxiway from the initial landing or departure of the aircraft. This affects the capacity calculation, where the number of exit taxiways from the runway for landing and exiting the apron for departures will increase the runway capacity, while the exit distance corresponding to the number of exit taxiways will also increase the existing capacity. Based on the present arrivals and the appropriate number of exit taxiways, the exit factor can be determined based on the graphs provided in AC 150/5060-5 (FAA, 1983).

Base capacity (Cb) is determined based on the available charts in AC 150/5060, percent arrival and mix index. After getting the basic capacity, then calculate the capacity per runway hour using the following equation (FAA, 1983) that the capacity per hour is obtained by multiplying the base capacity with the exit factor and the Touch and go factor. The next process of data processing is data analysis, which includes the activities of interpreting data and analyzing it (Priyono, 2008). Data analysis starts from searching for data, organizing it systematically, presenting it, and looking for meaning (Rijali, 2018). Based on the understanding of data analysis from previous researchers, in this study data analysis will be carried out starting from analyzing the collected data, presenting it and drawing a conclusion.

RESULT AND DISCUSSION

Based on the results of direct observation and data collection, the results and discussion of this study are described as follows.

Runway Configuration

SMB II Airport has 1 runway which is used for mixed operations, with runway and taxiway configurations which can be seen in the following figure.

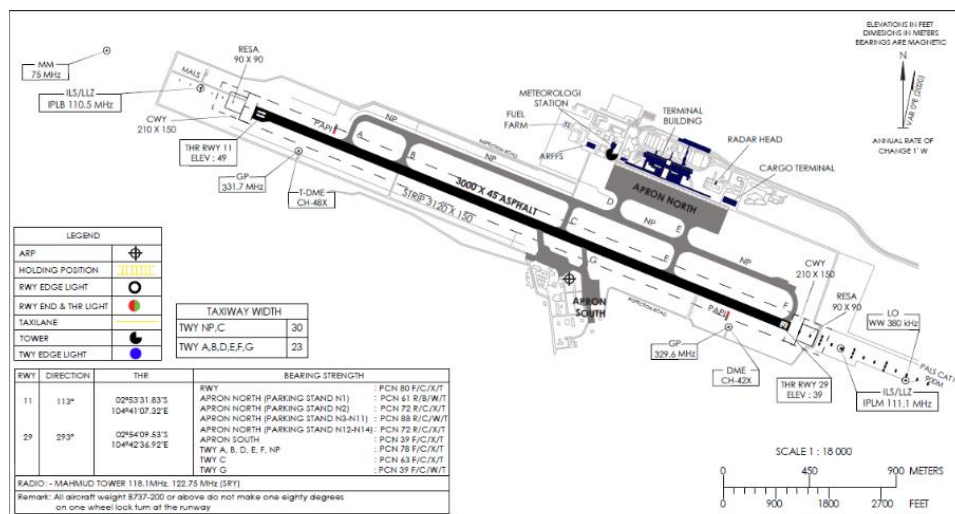


Figure 1. SMB II Airport Runway and Taxiway Configuration

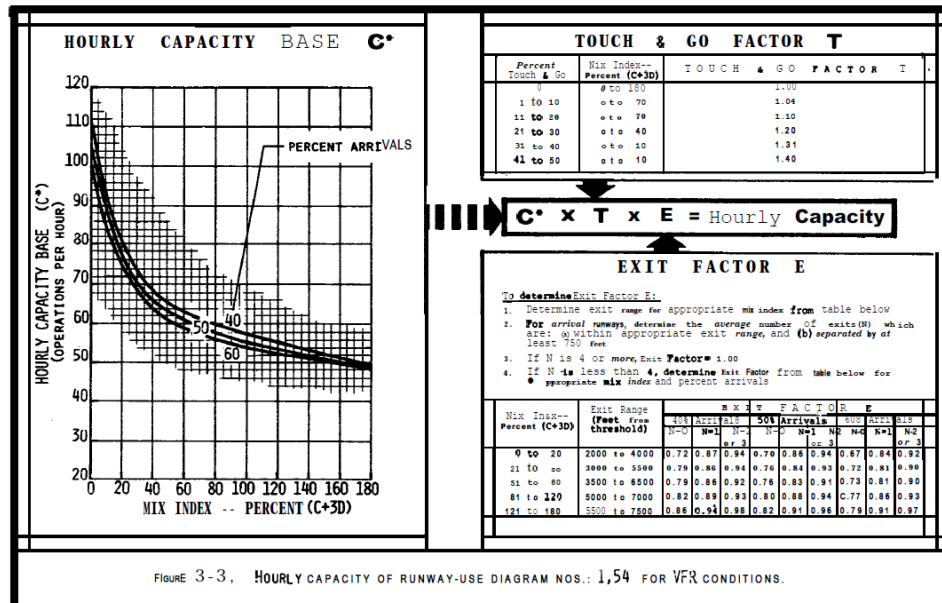
The SMB II Airport runway has a length of 3000 meters and a width of 45 meters, has 2 directions, namely 11 and 29. There are 5 exit taxiways namely A, B, C, E and F with each distance measured from the runway threshold 11 and 29 based on data provided taken directly from the SMB II Airport are as follows:

Table 2. Taxiway Exit Distance (meters)

Runway	Exit Taxiway				
	A	B	C	E	F
11	511.5	815	1720	2320	3000
29	2488.5	2185	1280	680	0

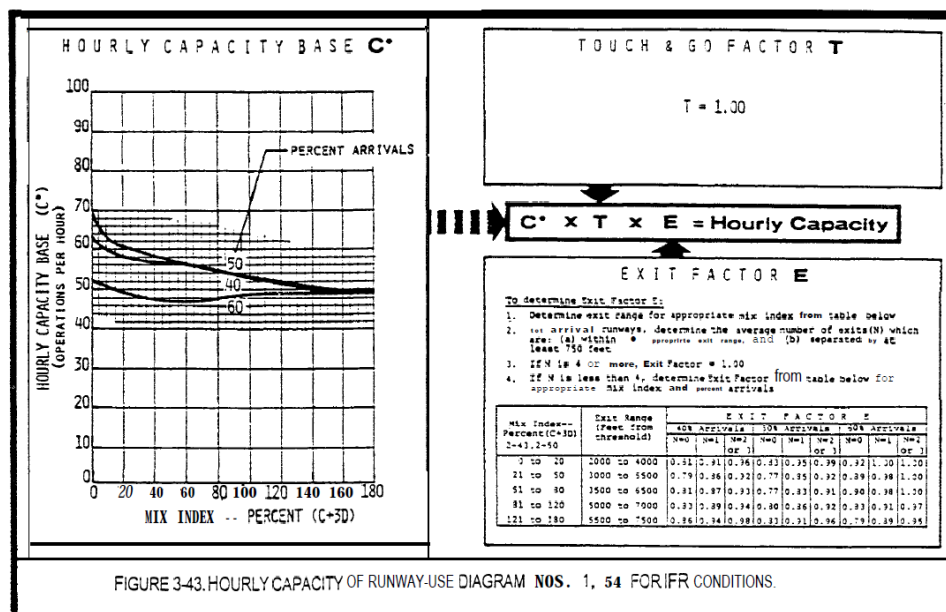
Source: Analysis Results, 2021

Based on the existing runway configuration, the calculation of runway capacity uses graphs 3-3 for VFR and 3-43 for IFR (FAA, 1983), which is as follows:



Source: (FAA, 1983)

Figure 2. Graph 3-3 (VFR)



Source: (FAA, 1983)

Figure 3. Chart 3-43 (VFR)

Calculation of Mix Index

Based on air transportation data for 2018-2020 obtained from SMB II Airport, aircraft operating at SMB II Airport can be classified as follows:

Table 3. Mix Index Calculation

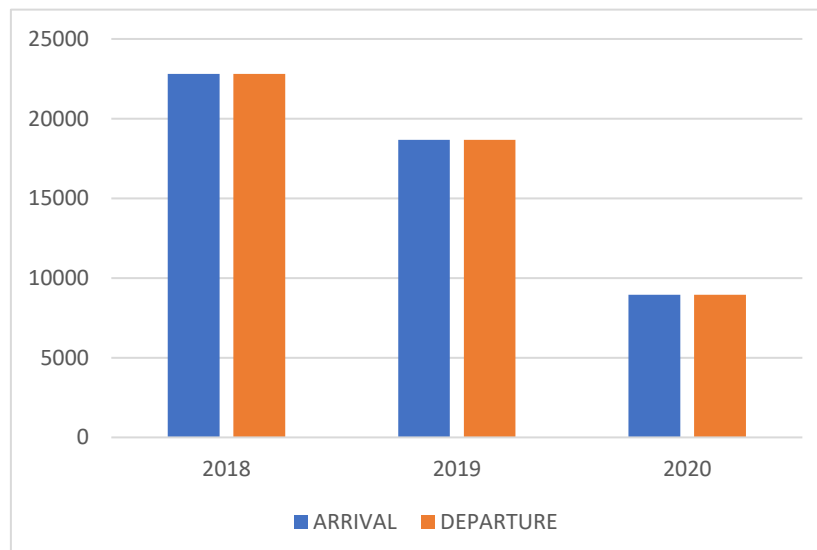
Year	CLASSIFICATION					MI
	A	C	D	helicopter	Invalid	
2018	6.8	91.8	0.5	0.7	0.2	93.4
2019	4.7	93.8	0.6	0.8	0.2	95.5
2020	10.3	88.0	0.3	1.1	0.4	88.8
Average	7.3	91.2	0.5	0.8	0.2	92.6

Source: Analysis Results, 2021

From these data, it is found that the average operating class A aircraft is 7.3%, class C is 91.2%, class D is 0.5%, helicopter is 0.8% and invalid is 0.2%. . Invalid is caused by the type of aircraft recorded data is not clear so that the author can not classify. Next, the mix index is calculated using the formula $MI=C+3D$, and the average mix index is 92.6.

Touch and Go Factor Calculation

Calculation *Touch and Go Factor* done by previously calculating percent arrival and percent Touch and Go. Based on air transportation data for 2018-2020 obtained from the SMB II Airport, the departure and arrival data are as follows.



Source: Analysis Results, 2021

Figure 4. Aircraft Arrival and Departure Data for 2018-2020

Based on the data above, there was a very significant decrease in the number of aircraft operating at SMB II Airport. The decline from 2018 to 2019 was due to an increase in air ticket fares, while the decline from 2019 to 2020 was due to the impact of the COVID-19 pandemic. This is in accordance with research that has been done previously. The increase in airfare fares has an impact on the decline in passengers. The number of passengers departed in January 2019 decreased by 16.7% compared to December 2018 and decreased by 12.55% compared to January 2018 (Wirabrata, 2019). No operation *Touch and go* recorded, so percent Touch and Go is 0%. As for percent arrival is 50% because the number of arrivals and departures is balanced. Based on graph 3-3 in Figure 2, for percent *Touch and Go* is 0% and *mix index* is 50%, then *Touch & Go Factor*(T) is 1. Meanwhile, based on graph 3-43 in Figure 3, *Touch and Go Factor*(T) is 1 regardless of percent Touch and Go and mix index.

Exit Factor Calculation

exit factor(E) is calculated from both runway directions because the exit taxiway distance from the runway threshold in terms of directions 11 and 29 is different. Based on graph 3-3 in Figure 2 and Graph 3-43 in Figure 3, for the mix index 92.6, the exit taxiways that are taken into account are only those that are 5000 feet (1524 meters) to 7000 feet (2134 meters) from the runway threshold, and are separated from each other. a minimum of 750 feet (229 meters) between exit taxiways. So that in terms of the direction of runway

11 the number of exit taxiways that are taken into account (N) is only 3, namely exit taxiways C, E and F. While in terms of the direction of runway 29, the number of exit taxiways that are taken into account (N) is only 2, namely exit taxiways A and B. By using Figure 2 and Figure 3, Percent Arrival 50%, N by 3 and 2, then the Exit factor value is:

Table 4. Exit Factor Nilai

Runway Direction	Percent Arrival	N	Exit Factor	
			VFR	IFR
11	50%	3	0.94	0.92
29	50%	2	0.88	0.86

Source: Analysis Results, 2021

Runway Capacity

Basic capacity (Cb) based on graph 3-3 (VFR) in Figure 2, with 50% arrival percent and mix index 92.6, Cb is 57. Meanwhile, based on graph 3-42 (IFR) in Figure 3 with 50% arrival percent and the mix index is 92.6 then Cb is 54. Then the runway saturation capacity per hour (C) in terms of both directions of the runway is calculated by the formula $C = C_b \times E \times T$, which is as follows:

Table 5. Runway Capacity Per Hour

Runway	T	Cb		E		C	
		VFR	IFR	VFR	IFR	VFR	IFR
11	1	57	54	0.94	0.9	53.6	49.7
29	1	57	54	0.88	0.9	50.2	46.4
Average						51.9	48.1

Source: Analysis Results, 2021

The hourly runway saturation capacity for runway 11 directions is 53 (VFR) and 49 (IFR), while for runway 29 directions it is 50 (VFR) and 46 (IFR). So that the average capacity of both runway directions is 51 (VFR) and 48 (IFR). The hourly runway capacity of the two runway directions is different, because it has a different exit factor value.

Calculation Result Analysis

One of the factors that affect runway capacity is the separation rules for the flight traffic control system (Horonjeff et al., 2010). However, in calculating the runway capacity provided by the FAA, the rules for the separation of the air traffic control system are fixed and cannot be changed, and are presented in graphical form. This means that the calculation of the runway capacity will be valid if SMB II Airport applies the same flight traffic separation rules as the FAA. The flight traffic separation rules applied by SMB II Airport are based on the Standard Operating Procedures owned by Airnav Indonesia Palembang branch, different from the flight traffic rules applied by the FAA (Neufville & Odoni, 2013). Where in general the comparison is presented as follows:

Table 6. Aviation Traffic Separation Comparison

Operation Order	Aviation Traffic Separation	
	FAA	SMB II
Arrival-Departure	Clear Runway	Clear Runway
Departure-Arrival	Arrival/ at least 2 nm from the runway threshold	Arrival/ at least 8 nm from the start of the runway
Departure-Departure	45 to 120 seconds (depending on the type of aircraft)	1 to 2 minutes (depending on the type of aircraft)
Arrival-Arrival	3 to 5 nm (depending on aircraft type)	6 nm from touchdown runway

Source: Analysis Results, 2021

Based on the table above, the flight traffic separation rules applied at SMB II Airport as a whole are relatively larger than those applied by the FAA. In departure operations followed by arrival, FAA applies a separation of 2 nm from the runway threshold for incoming aircraft, while SMB II Airport applies 8 nm from the end of the runway for arriving aircraft. Likewise for arrival operations followed by arrival, where FAA applies 3 to 5 nm depending on the type of aircraft operating, while SMB II Airport applies 6 nm for all types of aircraft. Air traffic separation rules have an important influence on runway capacity (Safriallah & Putra, 2017). So that to increase runway capacity, it can be done by reducing the separation between operating aircraft. The runway saturation capacity analysis is based on the advisory circular 150/5060-5 which has been

used as a study material in the field of airport management. The results of application in learning based on student learning outcomes are presented in [Table 7](#).

Table 7. Student learning outcomes

Value Range	The number of students
50 – 69	11
70 – 80	20
81 – 84	64
>85	95

Indonesia is a member of the International Civil Aviation Organization known as the International Civil Aviation Organization (ICAO), where Indonesia must comply with and comply with the Standard and Recommended Practices (SARPs) issued by ICAO ([Santoso, 2017](#)). Air traffic separation rules regulated by ICAO include the minimum separation between aircraft departing on the same runway, namely (1) 1 minute separation is determined if the aircraft in front turns at least 45 immediately after takeoff, and (2) a minimum separation of 2 minutes is established between LIGHT or MEDIUM aircraft taking off behind HEAVY aircraft, and specified for LIGHT aircraft taking off behind MEDIUM aircraft ([ICAO, 2016](#)). This separation rule is also applied in SMB II.

The separation used by ICAO between incoming aircraft is using a minimum horizontal radar separation of 5 nm, but SMB II Airport uses 6 nm from the touchdown runway. Likewise for arriving aircraft followed by departing aircraft, ICAO uses a minimum horizontal radar separation of 5 nm, while SMB II Airport uses the separation rule, arriving aircraft is at least 8 nm from the end of the runway. In both of these conditions, SMB II applies separation rules that exceed ICAO. The separation rules applied by ICAO are minimal separation, so that member countries may set separation rules that exceed ICAO's separation rules. So to increase runway capacity, the separation rules applied by SMB II Airport are still possible to be reduced following the ICAO separation rules.

In general, the main functions of management consist of planning, staffing, organizing, directing, and controlling ([Gesi et al., 2019](#); [Husaini & Fitria, 2019](#)). Likewise with the field of airport management, one of which focuses on airport planning, especially calculating the existing capacity. So that this research can be used as study material in learning the field of airport management. Journals are scientific publications that present the latest scientific information and have a strategic role in the development and dissemination of knowledge. In order to support the achievement of research-based universities, integration between teaching and research is important to be implemented in higher education. The use of scientific journals as learning materials is an alternative to the lack of research performance ([Pratama, 2017](#)). Learning resources can develop various potentials such as the abilities, attitudes and interests of students ([Suhirman, 2018](#)).

CONCLUSION

The calculation of the saturated capacity of the SMB II Airport runway uses the method developed by the FAA and specified in the Advisory Circular 150/5060-5. Based on the existing data processing, the runway saturation capacity per hour for runway 11 direction is 53 in VFR conditions and 49 in IFR conditions, while for runway 29 directions it is 50 in VFR conditions and 46 in IFR conditions. So that the average saturation capacity for both runway directions is 51 in VFR conditions and 48 in IFR conditions. The calculation of runway saturation capacity with this method cannot accommodate differences in the flight traffic separation rules used. So that the runway capacity will be achieved, if applying the same separation rules as the FAA. The separation applied by Airnav Indonesia Palembang Branch in particular for inter-arrival and departure operations followed by arrivals is greater than that stipulated by the FAA and also ICAO. As an ICAO member country, the separation rules applied by Airnav Indonesia Palembang Branch can still be reduced following those set by ICAO so as to increase runway capacity. The results of this study can be used as study material in learning the field of airport management, given the lack of learning materials in the field of research-based airport management. Further research is needed to calculate the saturated capacity of the SMB II Airport runway, using a method that can accommodate the currently applied air traffic separation rules.

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