THE CAPACITY AND CIRCULATION OF PASSENGER TERMINAL BUILDING IN REGIONAL AIRPORT
(CASE: MINANGKABAU AND ADISUTJIPTO INTERNATIONAL AIRPORTS OF INDONESIA)

Amalia Defiani
Airport infrastructure planner, Ministry of Transport, Republic of Indonesia
E-mail: amalia.defiani@gmail.com

ABSTRACT

The dissertation explains about capacity and flow inside terminal buildings in two regional airports in Indonesia: Minangkabau and Adisutjipto International Airports. Both airports have similar characteristics of passengers' number and locations as tourism areas. Secondary data in the form of existing terminal layouts and air traffic numbers were gained from both airports authorities in Indonesia. The analysis was carried out using the formulas from Japan International Cooperation Agency – Directorate General of Civil Aviation of Indonesia(JICA-DGCA) studies in 1996 for significant areas in the terminal building, Ashford and Wright formula for calculating aircraft movement per hour, Microsoft Excel for calculating the 10-year passenger growth rate, and SPSS for determining the linear equation for domestic departure resulted in the forecasted saturation in the near 2020 for both of airports, especially on passengers' handling areas such as boarding lounge (for departure) and baggage claim area (for arrival). The research resulted in ideas to overcome problems related to the increasing capacity by adding areas (if possible) and changing layouts. Some other options such as implementation of more effective signage and the suggestion of centralising security checking areas also are being brought—though needed further research. There should be an addition of numbers of security check lines, appropriately to the increasing number of passengers. If a single queuing line creates delays, then the need for extra line(s) is a necessity

Keywords: Airport, Terminal Building, Capacity, Flow, Minangkabau, Adisutjipto

1. INTRODUCTION

For the last ten years, Indonesia has been experiencing a rapid growth caused by the implementation of low cost carrier (cheap flight) in almost every destination in Indonesia, causing capacity and flow difficulties within airport terminals. This study examines how effective the existing terminal layouts cope with the rapidly increasing passenger numbers in order to avoid future problems such as saturation or immovability inside the terminal buildings, and safeguarding passenger through airport security and safety.

Considering there are more than 250 general and special airports throughout Indonesia, this research only focuses on two medium sized airports which are: Adisutjipto International Airport - Yogyakarta, and Minangkabau International Airport - West Sumatera. Both serve as regional airports that have similar traits as rapidly growing airports and serve as eminent tourism destinations in Indonesia. These airports were chosen to study as the existing layout of the terminal buildings were known and data on passenger traffic for the last ten years was available.

Airport terminal design studies are generally undertaken by established consultancies that specialise in airport design. Academic studies tend to concentrate on aspects of terminal use and function. There is a journal mainly discussing about passenger flow related to aircraft schedules, the use of defining bottlenecks on the passenger flow and the logistics (JAMES, 2009); mainly discussing about the air-side movement (BAIK & TRANI, 2000); and discreting event passenger flow simulation model for an airport terminal capacity analysis (RAUCH & Miroljub, 2006). There is also a journal, which covers a topic about passenger handling at airport terminals based by modeling stochastic passengers' behavior (Schultz & Hartmut, 2011).

The purpose of this research is:

1. To make analysis about the designated existing regional airport terminal building;
2. To compare and see the difference of the existing terminals on both airports;
3. To propose suggestions of layout on passengers' handling facilities for the airports.

The research would lead to:

1. Clear description about the comparison of designated regional airports.

2. Serving literature in consideration of designing a terminal building, especially in Indonesia.

2. LITERATURE REVIEW

2.1 Area Calculation on Terminal Building

The formulas used in this research are from the studies of JICA-DGCA (1996) for calculations of each area inside the terminal building and ICAO (1985) and for forecasting the capacity of the airport terminal buildings. JICA had been conducting planning and design in some crucial airports in Indonesia, and those formulas were derived through empirical studies along the years since the projects started.

The formulas used on this thesis are:

Domestic line queue calculation from JICA-DGCA (1996):

$$N= P \times \alpha \times (t \div 3{,}600) \times B \quad (1)$$

Where:

N = necessary number of counters (issuance, check-in, baggage check-in)

P = number of passengers at the peak time

α = imbalance ratio (Issuance and reservation: 30 %, check-in: 100 %, baggage check-in: 80 %)

t = processing time (issuance and reservation: 90 second, check-in: 20 second, baggage check-in: 30 sec)

B = extra rate (1.3)

Area of Departure Lobby; JICA-DGCA (1996):

$$S= P \times (1+\alpha)(T \div 60) \times A \quad (2)$$

Where:

S = area of departure lobby (m2)

P = number of departing passengers at the peak time

α = number of people who see passengers off (international: 0.5, domestic: 0.2)*

T = passenger staying time (international: 30 min., domestic: 10 min.)

A = necessary space per passenger (international: 2.5 m2, domestic: 2 m2)

Gate lounge type boarding room;JICA-DGCA (1996):

$$S=FS \times LF \times ((M1 \times A1) + (M2 \times A2)) \times D \quad (3)$$

Where:

S = area of gate lounge (m^2)

FS = number of seats offered by plane

LF = load factor

M1 = standing rate (0.25)

M2 = seating rate (0.75)

A1 = space necessary per standing passenger (1.0 m^2)

A2 = space necessary per seating passenger (1.5 m^2)

D = accompanying space rate (1.3)

Baggage claim area; JICA-DGCA (1996):

$$S=PF \times (AF \div 60) \times B \quad (4)$$

Where:

S = area of baggage claim (m2)

PF = number of flights arriving at the peak time per baggage conveyor

M2 = seating Rate (0.75)

A1 = space necessary per standing passenger (1.0 m2)

A2 = space necessary per seating passenger (1.5 m2)

D = accompanying space rate (1.3)

Number of security equipment; JICA-DGCA (1996):

$$N= P10 \times (t1 \div 60) \times A \quad (5)$$

Where:

N = the number of security check equipment

P10 = number of passengers during the 10-minute peak period

t1 = processing time (8 sec.)

α = safety rate (1.2)

Area of security check; JICA-DGCA (1996):

$$S= N \times W \times D \quad (6)$$

Where:

N = security booth

W = width of one booth (m)

D = space for queuing (m)

The calculation using the SPSS program would resulted in determining the values of a and b in each of the linear regression formula of $Y = a + b X$. Y is a number of annual passenger movements, while X is the forecasted year. If Y has been obtained, than the formula from Ashford and Wright (1992) could be used for getting a peak hour flow. The formula contains of four steps:

Average monthly passengers
= 0.08417 x annual passenger flow

Average daily passengers
= 0.03226 x average monthly flow

Peak day flow
= 1.26 x average daily flow

Peak hour flow
= 0.0917 x peak daily flow (7)

2.2 Methods of Forecasting Traffic

There are three methods being used, these are: trend projection, econometric relationship, and market and industry surveys (ICAO, 1985). This research would focus on using a trend projection, in a form of linear equation. ICAO (1985) stated mathematical equations as different types of trend curves represented in trend projection. In each case, variable Y is traffic, the independent variable T is time (usually measured in years), and a, b, and c are all constants (or coefficients) which values can be estimated from the data.

2.3 Passenger Behaviour in the Terminal

Reflection of awareness to passenger's needs and behaviour must be reflected throughout the terminal design. Nevertheless, passenger's behaviour varied in accordance to the purpose of the trip, the flight logistics, and the type of flight.

3. RESEARCH METHODOLOGY

3.1 Research Variable

The research would be more focused on certain areas on passenger handling facilities, which covers check-in area, boarding lounge, baggage claim, and security check in, these are the areas considered as highly relevant to the bearing capacity of passenger flow.

3.2 Research Data and Location

This research is constrained on only using data from year 2010 of 10 preceding years, with the locations of airports that have been said previously, Adisutjipto Airport – Yogyakarta, and Minangkabau Airport – West Sumatera to be focused more on existing layout and the 10-year traffic data. There are differences between Adisutjipto and Minangkabau regarding location; Adisutjipto is located in the heart of the city of Yogyakarta, while Minangkabau is located 23 kilometres from Padang, the capital city of the West Sumatra Province. Nevertheless, they have similar characteristics as tourism spots and also the airport functioned as regional ones and both served international flights.

3.3 Research Scope

The Research scope consists of circulation and development; each of which is broken down into smaller subsequent parts. Circulation consists of basic shape of terminal building, capacity, composition, and passengers' number; development on the other hand consists of forecasting only. Each of the components is then measured for making up ample requirements. If the requirements fulfilled, then a terminal area would be obtained.

4. RESULT AND DISCUSSION

4.1 Architectural Review of the Terminal Building

A simple building concept is similarly used on both terminals, where a single common waiting area with several exits to the parking apron. Both of the terminal buildings has similar characteristics of passengers and an ample close-in public parking, with curb façade for loading/unloading of land transport.

The flow of passenger on single or double level terminal is shown on Figure 1.

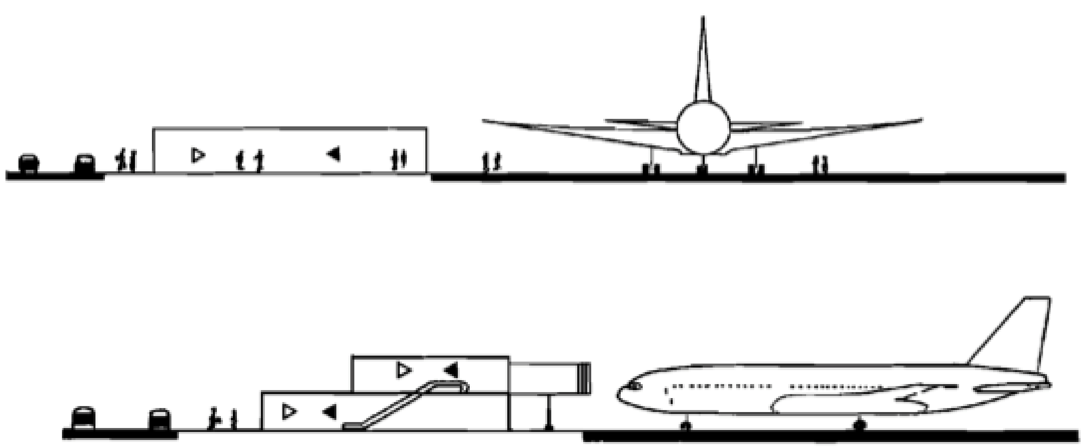

Figure 1 Single level road/single level terminal (above) and single level road/double level terminal (below) (ICAO, 1987)

The flow on Adisutjipto international airport, departure and arrival are divided and both are using single level flow, while in Minangkabau they are double level. The depart passenger would enter the check-in lobby after the security check, and then do the second security check before entering the boarding lounge to wait for the flight. Twice the security check delays the flow of passengers, as the long queue always built-up right before entering the boarding lounge. The problem also occurred in Minangkabau, but the space for queuing in Adisutjipto is much less than in Minangkabau. The arrival flow inside Adisutjipto International Airport terminal is rather simple. After walking from apron, passenger would immediately enter the baggage claim area and soon after could go to the exit near the curb side, while in Minangkabau the passenger arrived in Air Bridge to arrival corridor and then baggage claim downstairs.

4.2 Calculation of Terminal Area

The calculation is limited on areas that endure high domestic passengers' flow in peak hours and significantly affected the sequence inside of the terminal building. Considerably, there are four areas being observed: check-in area, boarding room, baggage claim, and security check.

4.2.1 Minangkabau area calculations

a) Check-in Area

The number of passengers could be defined in two possible ways. The first one is by using the formula of Domestic line queue calculation from JICA-DGCA (1996).

If the number of check-in counters is 18, then the number of passengers for peak time (P) can be calculated using formula (1)

$N= P \times \alpha \times (t \div 3{,}600) \times B$
$18= P \times 100\% \times (20/3600) \times 1.3$
$P= 18/(1/180 \times 1.3) =2492.31$

The second calculation is by using the formula (2)

The area of domestic check-in is 462 m2 (from the terminal plan)

$S= P \times (1+\alpha)(T \div 60) \times A$
$462= P \times (1+0) (10/60) \times A$
$P= 462/ (1/3) = 1386$ passenger/hour

b) Boarding room

The number of seats (FS) offered by plane would be acquired from the gate lounge type boarding room formula from JICA-DGCA (1996)

Load Factor is determined to 70% (Kazda & Caves, 2007) and is stated as the proportion of passenger.miles transported compared to the airplane seat.miles controlled in the system (e.g., passenger.kilometers/airplane seat.kilometers). Load factors are indulged to worldwide variations and sturdy variation in seasonal and daily peaking patterns for planning purposes and as average system

The area of the boarding lounge is 1000 m2 (from the airport plan)

$S=FS \times LF \times ((M1 \times A1) + (M2 \times A2)) \times D$
$1000= FS \times 0.7 \times (0.25+0.75) \times 1.3$
$FS= 1000/ (1.5 \times 0.7) = 952.38$ passenger/hour

c) Baggage claim area

The number of flights arriving in the peak time (PF) would be acquired from baggage claim area formula from JICA-DGCA (1996)

The area of the baggage claim is 1050 m2 (from the airport plan)

$S=PF \times (AF \div 60) \times B$
$1050= PF \times (AF/60) \times B$
$PF= 1050 / (1/3 \times 350) = 9$ flights $= 9 \times 160$ pax/aircraft= 1,440 pass./hour

d) Security check area

There are two calculations for the security check area, one for determining P10 (number of passengers during the 10-minute peak period) and the other is for determining space for queuing (D)

Calculating the number of security check equipment
It is known from the airport plan that the number of security check equipment is 3

$N= P10 \times (t1 \div 60) \times A$
$3= P10 \times (8 / 60) \times 1.2$
$P10= 3/0.16 = 18.75 \approx 19$ persons

Queuing line in area of security check
S is 131 m^2 (from the airport plan)
$S=N \times W \times D$
$131= 3 \times 5.5 \times D$
$D= 131 / (3 \times 5.5) = 7.9 \approx 8$ m

4.2.2 Adisutjipto area calculations

Respectfully, the calculation method would be similar with ones of Minangkabau Airport, with different results that would be described thoroughly in the full report of this research.

Table 1 Domestic passenger growth of Minangkabau International Airport

Year	Year of	Departure	Arrival	Total	Departure growth	Arrival growth	Total growth
2001	1	138,738	135,387	218,925	0.35	0.35	0.20
2002	2	212,433	208,397	274,125	0.48	0.49	0.35
2003	3	411,254	404,674	420,830	0.33	0.32	0.48
2004	4	610,197	595,767	815,928	0.07	0.05	0.34
2005	5	652,890	628,873	1,229,274	0.13	0.16	0.18
2006	6	746,875	748,094	1,499,437	0.08	0.07	0.09
2007	7	810,848	807,769	1,638,897	-0.10	-0.10	-0.10
2008	8	737,152	733,110	1,493,281	0.10	0.11	0.10
2009	9	822,275	825,911	1,664,728	0.08	0.08	0.08
2010	10	897,017	895,031	1,800,906			
				Total	1.51	1.53	1.72
				Average	0.17	0.17	0.19

4.3 Passenger Growth

The rate of passenger growth can be determined by simple calculation of percentage comparison, where average growth of 10 years percentage is the sum of percentage (respectively to departure, arrival, or total growth) divided by nine. Table 1 showed the domestic passenger growth rate in Minangkabau International Airport.

The ten-year growth of departure and arrival of domestic flights for Minangkabau is 17% while the total growth is 19%.

The ten-year growth of departure and arrival, and also for the total growth of domestic flights for Adisutjipto is 12% (the table of growth is in the full report).

Since the growth rate is stable for both of the airports throughout the year and the data input is restricted to ten years of operation, the method for forecasting being used in this research is by simple linear regressions.

4.4 Forecasting

The forecasting was done with SPSS linear regression in order to obtain the formula for both domestic departure and arrival growth of the two airports by obtaining the coefficient from the results of the SPSS running. The R square is being observed in order to know the level of influence of the variable. The result of the calculation would be the forecasted passenger growth, which will then be used for obtaining the hourly aircraft movement using the formula from Ashford and Wright (1992).

a) Minangkabau departure forecasting

The R square stated as 0.875, which means that the variable has strong contribution on the growth. Regression equation is said to be Y= a + bX. The equation obtained from the SPSS coefficient table is:
Y = 156673.467 + 81326.26 X

Using formula from the regression (for getting the annual passenger flow) and from Ashford and Wright (1992), peak hourly of passenger movement can be obtained.

If the year variable of X is filled with 11 (which means year 11 is to be forecasted), then we can obtain the number of annual passenger flow, as follows:

Y= 156673.467 + 81326.26 X
Y= 156673.467 + (81326.26 x 11)
Y = 1,051,262.327

Ashford and Wright (1992) break down the formula into four steps for getting the peak hour flow:

Average monthly passengers
= 0.08417 x 1,051,262.327
= 88,484.75006

Average daily passengers
= 0.03226 x 88,484.75006
= 2,854.518037

Peak day flow
= 1.26 x 2,854.518037
= 3,596.692727

Peak hour flow
= 0.0917 x 3,596.692727
= 329.816723 ≈ 330 passengers

b) Minangkabau arrival forecasting

The R square stated as 0.885, which means that the variable has strong contribution on the growth. Table 5.4 showed the coefficients for the linear equation. The equation obtained from the SPSS coefficient table is:

Y= 146,407.933 + 82162.43 X

If the year variable of X is filled with 11 (which means year 11 is to be forecasted), then we can obtain the number of annual passenger flow, as follows:

Y= 146,407.933 + 82162.43 X
Y= 146,407.933 + (82162.43 x 11)
Y = 1,050,194.663 passengers

We can now put the number of annual passenger flow from the regression of year 11 into the first step and so on of the Ashford and Wright formula, and would result in these steps, and resulted in 330 passengers flow per hour. Using the same method, in 20 years of time the peak hour passenger flow forecasted to be 560 passengers per hour.

c) Adisutjipto departure and arrival forecasting

Respectfully, the calculation method would be similar with ones of Minangkabau Airport, with different results that would be described thoroughly in the full report of this research.

4.5 Comprehensive Analysis

a) Calculation of the terminal area analysis

The comparison would cover check-in area, boarding room, baggage claim, and security check where the existing and forecasted traffic is being observed. ‘

Table 2 Minangkabau Capacity and Flow Analysis

No	Facility	Area (m^2)	Capacity	Demand (flow)		Volume/ capacity		Action/comment
				2011	2020	2011	2020	
1	Check-in area	462	439	330	560	1.4	0.825	Need expansion for 2020
2	Boarding Room	1000	960	480	800	2.1	1.25	Still adequate
3	Baggage claim	672	1440	480	800	1.4	0.84	Need expansion for 2020
4	Security check area	131	19	21	99	1.1	5.2	Need optimizing

Table 3 Adisutjipto Capacity and Flow Analysis

No	Facility	Area (m^2)	Capacity	Demand (flow)		Volume/ capacity		Action/comment
				2011	2020	2011	2020	
1	Check-in area	600	570	546	892	1.1	0.67	Need expansion for 2020
2	Boarding Room	1300	1280	800	1280	1.625	1.02	Almost over capacity on 2020
3	Baggage claim	1820	2560	800	1280	2.275	1.42	Still adequate
4	Security check area	60	13	13	64	1	5	Need optimizing

b) Existing flow analysis on terminal building

Some of the passengers’ handling facilities are still adequate or maybe made more than the needed capacity but the others are soon to be over capacity. The layout changing might be needed in each area, especially to increase capacity in areas that need more space. The example of the existing layout is now is shown on **figure 2**.

The idea is to simplify the flow after check-in to the boarding lounge, which would also relate to the decentralized security checking, which would result in delays. The increasing capacity alone could not be fully helpful if the flow is still not swiftly gone through.

c) Delay cause analysis

Both of the terminal buildings are linear in shapes: differentiate only in the number of stories; Adisutjipto is a single-level terminal building (see figure 2 of Adisucipto layout), while Minangkabau is a two-level terminal building. The flow of passenger inside the terminal building is also typical, with bottleneck on certain areas where queues were located. There is also separation between departure and arrival, where the flow of both activities is not mixed.

One of the causes of saturation is the delay in passengers’ handling facilities. If the delay in these facilities could be minimised, then the flow of passengers inside the terminal building could be enhanced (see also figure 2 and figure 3 for example of areas that clogged the flow of passenger).

Graphic devices were used to endorse areas (i.e., in check-in counters, departure gate, lounge) in order to retain full control and keep track of the passenger. This was done by airlines, by using master brand logo-type and this signs have relatively short life span (varied from three months to ten years).

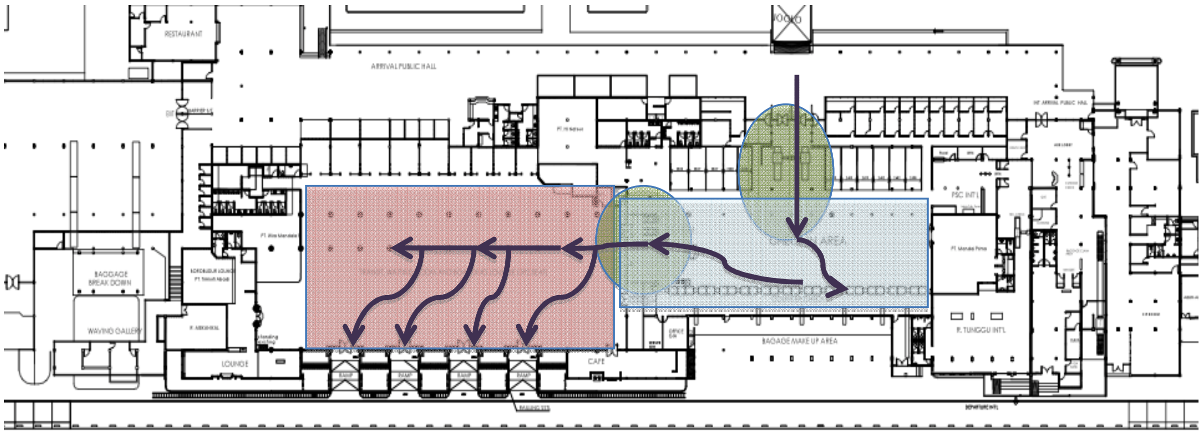

Figure 2 Layout of Adisutjipto international airport, needed more assessment on the percentage and layout of the facilities (red for boarding lounge, blue for check-in), and also the issue of decentralised security checking (the green areas)

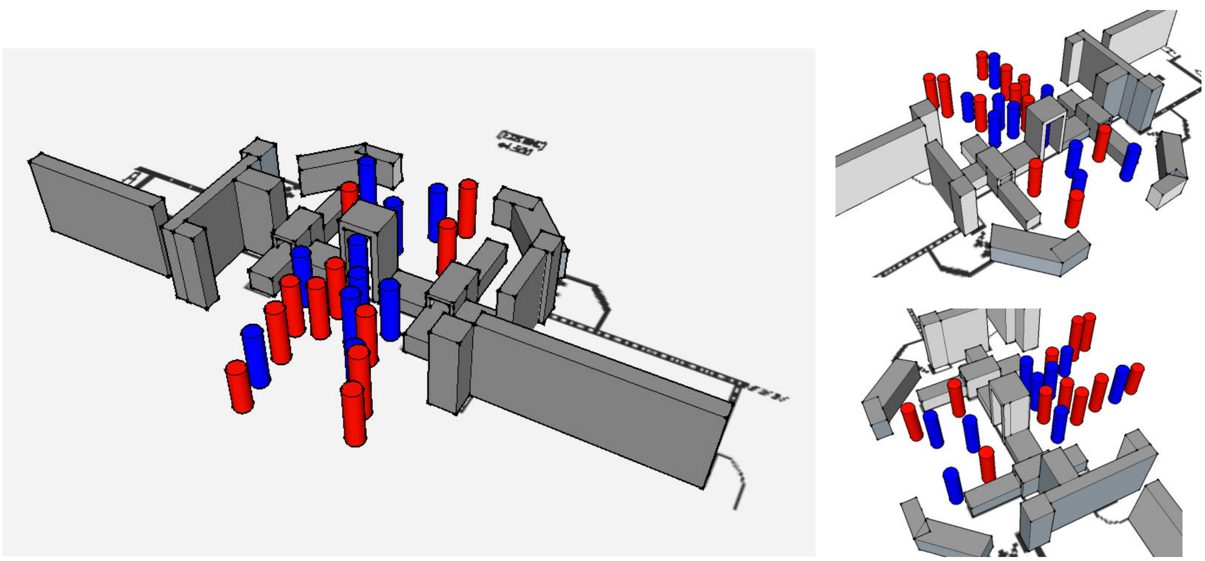

Figure 3 The illustration on how the flow of passenger is held by the security checking upon entering the boarding lounge on Minangkabau International Airport

The flow on figure 2 shows how the double security check blocked twice and thus created a delay for the passengers. There would also be a queue built up in the check-in area, and on the boarding room upon the boarding gate before entering the aeroplane.

The illustration on figure 3 shows how the queue was built up in front of the second security check while entering the domestic boarding room on Minangkabau International Airport. Using only one walk-in detector, the number of lines is forced to join into just singular line, making it more difficult to enhance the flow of passenger, which eventually creates delay.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

With respect to the analysis results obtained in this study, some conclusions can be presented as following descriptions:

a) As a result of saturation inside of the buildings, it is inevitable that airport itself acted as an organicbuilding with insatiable hunger for land expansion or consumption.

b) In the case of Minangkabau international airport, the expansion may not be a problem, since the airport itself located in the outskirt of the West Sumatra's capital city, Padang.

c) For Adisutjipto, the suggestion for building expansion is out of question, since not only the location of the airport itself stands alone inside the city and close to some hills as obstacles to the flights.

d) The necessity for optimising the existing areas inside the terminal would be a better idea to solve the problem, in case relocation is may be something that is out of the question.

5.2 Recommendation

Regarding to the findings and obtained results, some recommendations are proposed as follows:

a) There should be an addition of security check lines, appropriately to the increasing number of passengers. If a single queuing line creates delays, then the need for extra line(s) is a necessity.

b) There is also a need to simplify the security screening, to make it centralized in order to reduce delay of passenger's flow. Passengers can move freely without undergone another security check, and thus the common boarding lounge concept could be implemented. The optimising of signage also could be helpful in enhancing the flow inside the terminal area. A more detailed research—regarding flow of the passenger—is need to be conducted inside each of the terminal building in order to determine the effectiveness of the existing signage

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