Analysis the Needs for Express Railway Services to Support Multiple Airport System of Greater Jakarta

SUWARDO [a], Iman HARYANTO [b], WIRYANTA [c]

[a,b,c] *Diploma Program in Civil Engineering, Vocational School, Gadjah Mada University, Yogyakarta 55281, Indonesia*
[a] *E-mail: suwardo@mail.ugm.ac.id*
[b] *E-mail: imanh@ugm.ac.id*
[c] *E-mail: denmaswir@yahoo.com*

Abstract: This paper present the express railway services to support the development of West Java International Airport (WJIA). WJIA as a multiple airports system consists of Soekarno-Hatta International Airport (a primary airport) and Karawang and Majalengka Airport in West Java (secondary airport). The provision of express railway services will serve to and from multiple airports system. The analysis covers: 1) demand of public transport in multiple airports system, 2) study on the express railway service as a rational option mode, and 3) the needs of fleets and operating characteristics for railway services for express and mass transit. The results show that express railway system is a rational option mode between Soekarno-Hatta and Karawang and Majalengka Airport. The designed fleet is 8 cars - 100 seats with regard to predicted number of passengers for Karawang and Majalengka Airport, the departure frequency required by 4 trains per hour at headway of 15 minutes.

Keywords: express railway services, international airports, multiple airport system

1. INTRODUCTION

The development of interaction between Soekarno-Hatta International Airport (abbreviated SHIA) and the Karawang and Majalengka International Airport in West Java requires support of public transport. As the development of air transport infrastructure, construction of Karawang and Majalengka International Airport in West Java at least has two main functions. First, this is to reduce the density of aircraft movements and passengers at SHIA. Second, it can support the urban development and economic growth. Both functions at its optimum will be achieved if it is supported by land transport system as connection of these both airports. Efficient land transport system to support the relation between two airports is public transport.

Analysis of the needs of public transport modes for air passengers between Soekarno-Hatta International Airport (the primary airport) and Karawang and Majalengka International Airport in West Java (as a secondary airport) covers the main ideas as follows: 1) demand of public transport in multiple airports system, 2) study on the express railway service as a rational option mode, and 3) the needs of fleets and operating characteristics for railway services which is express and mass transit.

2. OBJECTIVES AND BENEFITS

The purpose of the study is to analyze the needs of fleets and operating characteristics for express railway services to support multiple airport system (MAS) of greater Jakarta, in West

Java International Airport (WJIA). Meanwhile, the express railway service is benefit to support the development of the West Java International Airport (WJIA). Express railway system as a land public transport served air passengers to and from multiple airports system.

3. THE PLANNING OF CAPACITY REQUIREMENTS AND OPERATING CHARACTERISTICS

Demand for public transport between Soekarno-Hatta International Airport and Majalengka and Karawang in West Java is estimated at 10 to 12 million people per year (Haryanto, et.al, 2012). Of the total amount will be served by the public transport system, so that the total passenger movement in both directions will reach 27,397-32,877 people per day. Assuming operating time of 12 hours per day then its demand be 2,284-2,740 people per hour. The demand need for public transport services with high capacity and rapid moving. Thus, it should be provided the right kind of public transport mode to serve the air passenger.

Study on road network system and the existing public transport can be used as consideration for the development of public transport. The public transit system to be studied is express train system based railway. The road networks and railway networks was evaluated such as condition, performance and capacity. The road network condition, route length, and its road performance will determine the performance and capacity of bus service. Meanwhile, the railway network conditions, length of service, rail performance will determine the performance and capacity of express train service. As shown in Figure 1, it can be estimated that the travel distance of air passenger using land public transport modes between main airports (SHIA) and the secondary airport (Karawang) is expected up to 90 km. Meanwhile, the travel distance between the main airport and the secondary airport (Majalengka) is up to 290 km.

The development of Karawang International Airport as a secondary airport and Soekarno-Hatta International Airport (main airport) requires the express public transport services on the land side to support the movement of air passengers between the two airports. There are two types of public transport such as express bus service (bus rapid transit, BRT) and the express train (railway express system, RRT). Air passengers will require the operating characteristics of public transport such as high capacity, rapid and safety. As the travel time, high capacity, and high security for express train service become a major consideration, so that the express train is preferred option compared with express bus services (BRT). In general, the public transport system is classified based on the type of service, routing and scheduling as shown in Figure 2 (Guenther, 1971). Rail Rapid Transit (RRT) system called the train moving on railway with a high speed rail lines and highest capacity. The RRT is chosen because its short waiting time regard to high service frequency. Moreover, in term of the routing RRT is suitable to few destination (start and end trip are both two airports).

To design the operating speed of railway system it can be used two commonly used standards in the world, namely: a) Standard of RRT system capacity, b) Standard of RRT system operating characteristics.

Figure 1. Locations and Hinterland of Soekarno-Hatta International Airport, Karawang and Majalengka Airport
(Source: Japan Ministry of Economy, Trade and Industry, 2012)

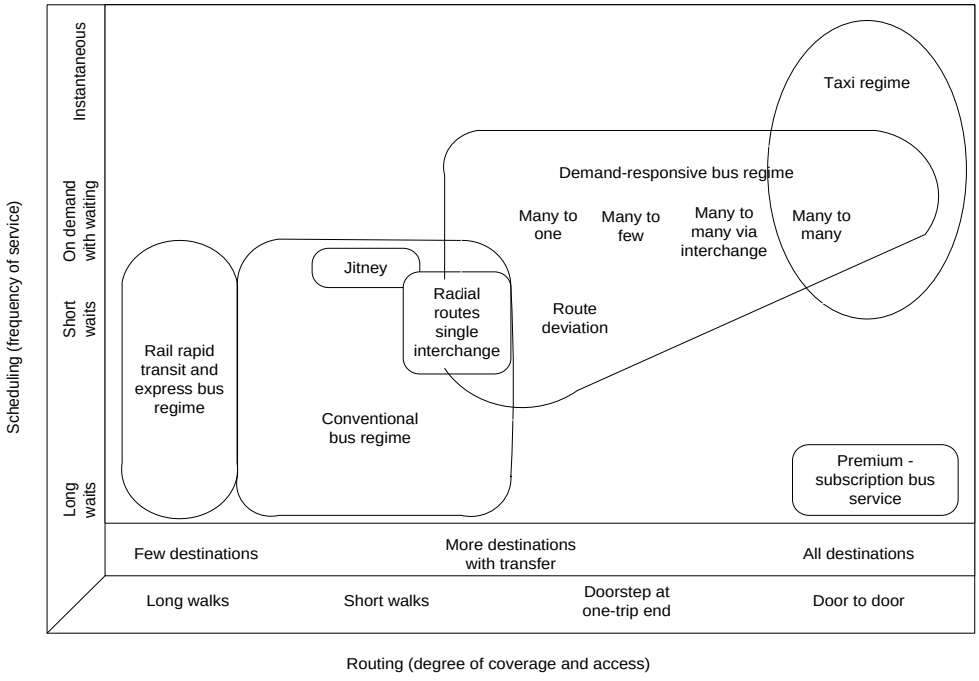

Figure 2. Public Transport System Routing and Scheduling Classified by Types
(Source: Guenther, 1971 as in Khisty and Lall, 2003)

3.1 Capacity Requirements of Express Railway System

a. Capacity of express railway system (rail rapid transit, RRT)

The capacity of a rail line is determined by the capacity of station or way capacity, but is generally determined by the capacity of the station. Capacity depends on (1) car size and length of train-station, (2) allowable standees as determined by scheduling policy, (3) minimum headway between trains. The minimum headway is a function not only of dwell time at major stations, but also length of train, acceleration and deceleration ratio, and train control systems.

Passenger capacity during peak hour can be estimated from the following equations:

$$Passengers/hour = \frac{trains}{hour} \times \frac{cars}{train} \times \frac{seats}{car} \times \frac{passengers}{seat} \quad (1)$$

or

$$Passengers/hour = \frac{cars}{hour} \times \frac{seats}{car} \times \frac{passengers}{seat} \quad (2)$$

or

$$Passengers/hour = \frac{trains}{hour} \times \frac{cars}{train} \times \frac{ft^2}{car} \div \frac{ft^2}{passenger} \quad (3)$$

b. Data for capacity analysis

1. Prediction of air passenger:
   a) Air passengers as being diverted from Soekarno-Hatta International Airport as primary airport in multiple airport system (MAS) to Karawang Airport or Majalengka Airport as secondary airport.
      As indicated in previous study by Haryanto, et.al (2012), the total air passengers diverted from MAS Jabodetabek area to Karawang Airport or Majalengka Airport is potentially about 10-12 million passengers per year or 27,397-32,877 passengers per day or 2,284-2,740 passengers per hour. These all passengers will be supported by public land transport with high capacity and operating speed characteristics which is express railway system.
      Therefore, air passengers = 2,740 passengers per hour
   b) Growth of passengers (generated passengers) as being estimated about 10% of air passengers.
      Air passengers/hour = 10% x 2,740 = 274 passengers/hour
   c) Total number of air passenger
      Air passengers/hour = 2,740 + 274 = 3,014 passengers/hour
2. Assumed:
   The number of cars (cars/train) = 8 cars
   The number of seats (seats/car) = 100 seats (2 rows, 50 seats per row)
   The number of passengers (passengers/seat) = 1 passengers
3. Calculated:
   From the Equation (1), it is obtained:
   The number of trains per hour = $\frac{trains}{hour} = \frac{3{,}014}{8 \times 100 \times 1} = 3.78$
   Number of trains = 3.78 $\approx$ 4 trains/hour
   Hence, the number of trains operated is 4 trains per hour. In other word, the frequency is 4 trains per hour. The arrival interval of trains (headway) is 15 minutes.

3.2 Analysis of Operating Characteristics of Express Railway System

The steps of calculation are summarized below.

1) The length (distance) of express railway lines is estimated as the following:
   a) Soetta - Jabodetabek = 20 km
   b) Jabodetabek - Karawang = 70 km
   c) Jabodetabek - Majalengka = 270 km
2) As the maximum operating speed = 80-100 km/h, the travel time are:
   a) Soetta - Karawang = 54 minutes (less than 1 hour)
   b) Soetta - Majalengka = 174 minutes (2 hours 54 minutes)

   The operating speed and travel time are presented in Table 1.
3) Productivity of express railway system
   a) Soetta - Karawang = 90 x 3,014 = 271,260 pass-km/h
   b) Soetta - Majalengka = 290 x 3,014 = 874,060 pass-km/h

   Recapitulation of operating characteristics of express railway system is presented in Table 2.

Table 1. The Operating Speed and Travel Time of Express Railway System

The relation of main and secondary airports	Distance (km)	Operating speed (km/h) *)			Train travel time (minutes)		
		min	normal	max	max	normal	min
Soetta-Karawang	90	24	25	80	225	216	68
		55	60	100	98	90	54
Soetta-Majalengka	290	24	25	80	725	696	218
		55	60	100	316	290	174

Note: *) Used value of the standard rail rapid transit.
min = operating speed approaching capacity; normal = normal operating speed; max = maximum technical speed

Table 2. The Summary of Operating Characteristics of Express Railway System (RRT)

No.	Characteristics	Notation	Unit	Value of RRT	Soetta - Karawang RRT Design	Soetta-Majalengka RRT Design
1.	Vehicle capacity	Cp	Sps/veh	140-280	100	100
2.	Vehicle / transit unit	-	veh/TU	1-10	8	8
3.	Transit unit capacity	-	sps/TU	140-2,000	800	800
4.	Maximum technical speed	V	km/h	80-100	80-100	80-100
5.	Maximum frequency	fc-max	TU/h	20-40	4	4
6.	Line capacity	C	sps/h	10,000 to 40,000	3,200	3,200
7.	Normal operating speed	Vo	km/h	25-60	25-60	25-60
8.	Operating speed at capacity	Vc-o	km/h	24-55	24-55	24-55
9.	Productive capacity	Pc	(Sp-km)/h x 10^3	400-1,800	271,260	874,060
10.	Lane width (oneway)	-	m	3.70-4.30	Not available	Not available
11.	Vehicle control	-	-	Man.-aut./sig.	Not available	Not available
12.	Reliability	-	-	Very high	Not available	Not available
13.	Safety	-	-	Very high	Not available	Not available
14.	Station spacing	-	m	500-2000	Not available	Not available
15.	Investment cost per pair of lanes	-	($/Km) x 10^4	8.0-25.0	Not available	Not available

4. CAPACITY REQUIREMENTS BASED ON SAFETY FACTOR AND PRACTICAL ASPECTS

The capacity requirements of express railway system (rail rapid transit, RRT) cover safety factor-base and practical aspects. The calculation was carried out as the follows.

4.1 Prediction of Passengers and Service Frequency

Based on the previous study (Haryanto, et.al, 2012), the predicted air passengers in 2019 and 2025 for Karawang Airport and Majalengka Airport are shown in Table 3 and Table 4, respectively.

Prediction of air passengers:

Total number of air passengers = air passengers diverted + air passengers generated

Air passengers/hour = (11,595,524/(365 x 12))x(100%+10%) = 2,912 pass/hour

Assumed:

The number of cars (cars/train) = 8 cars

The number of seats (seats/car) = 100 seats (2 rows, 50 seats per row)

The number of passengers (passengers/seat) = 1 passengers

Calculated:

From the Equation (1), it is obtained:

$$\text{The number of trains per hour} = \frac{trains}{hour} = \frac{2{,}912}{8 \times 100 \times 1} = 3.64$$

Number of trains = 3.64 ≈ 4 trains/hour

Hence, the number of trains operated is 4 trains per hour. In other word, the frequency is 4 trains per hour. The arrival interval of trains (headway) is 15 minutes.

The line capacity is estimated as follows:

Passengers/hour = 4 x 8 x 100 x 1 = 3,200 pass/hour

Table 3. Prediction of Air Passengers and Service Frequency for Karawang Airport

Year	Demand *) Karawang	Total **) (Pass/hour)	Frequency (Trains/hour)
2019	11,595,524	2,912	4
2025	17,402,549	4,370	6

Table 4. Prediction of Air Passengers and Service Frequency for Majalengka Airport

Year	Demand *) Majalengka	Total **) (Pass/hour)	Frequency (Trains/hour)
2019	388,984	98	1
2025	1,119,344	281	1

Note: *) Represents the value of Passenger Demand Sharing (PS) in passengers/year

**) Total passengers/hour was calculated by assuming the airport operating hour is 12 hours per day and passengers growth (generated passengers) by 10% of air passengers.

4.2 Determination of Headway

The headway (h_x) is determined based on the number of cars per train (p_x) (See Khisty and Lall, 2003). The determination of operating headway was simulated as follows:

Table 5. Assumption of Operating Headway Calculation

Second Airport	Year	Estimated Demand (pass/hour)	Frequency (trains/hour)
Karawang	2019	2,912	4
	2025	4,370	6
Majalengka	2019	98	1
	2025	281	1

Headway is calculated from the following equation:

$$C_x = 3600 \times \alpha \times \sigma \times p_x \times N / h_x \quad (4)$$

$$2{,}912 = 3600 \times 0.9 \times 0{,}9 \times p_x \times 100 / h_x$$

$$h_x = 10013 \times p_x \quad \text{or} \quad p_x = 0.010 \times h_x$$

where,

C_x = peak-hour demand (passengers/hour)
α = guide way utility factor, assumption = 0.9 (assumed that α is not approaching 1.0)
σ = load factor, assumption = 0.9 (assumed that σ is not approaching 1.0)
p_x = train length (cars/train)
h_x = headway (second)

4.2.1 Simulation of operating headway for Karawang Airport in 2019

Operating headway is simulated to the number of cars/train. The maximum length of train (cars/train) is 11 cars. The result was shown in Table 6.

Table 6. Operating Headway for Karawang Airport in 2019

C_x = 2,912

p_x (cars/train)	N = 100 seats (100%) h_x (Headways; minutes)	N = 120 seats (120%) h_x (Headways; minutes)	N = 130 seats (130%) h_x (Headways; minutes)	N = 140 seats (140%) h_x (Headways; minutes)	N = 150 seats (150%) h_x (Headways; minutes)
1	1.67	2.00	2.17	2.34	2.50
2	3.34	4.01	4.34	4.67	5.01
3	5.01	6.01	6.51	7.01	7.51
4	6.68	8.01	8.68	9.35	10.01
5	8.34	10.01	10.85	11.68	12.52
6	10.01 *	12.02	13.02	14.02	15.02
7	11.68 *	14.02	15.19	16.36	17.52
8	13.35 *	16.02	17.36	18.69	20.03
9	15.02 *	18.02	19.53	21.03	22.53
10	16.69	20.03	21.70	23.36	25.03
11	18.36	22.03	23.87	25.70	27.54

Note: *) Possible range of headway (h_x) is in the range of 10-15 minutes with regard to the length of train of 6, 7, 8, and 9 cras.

4.2.2 Simulation of operating headway for Karawang Airport in 2025

Operating headway is simulated to the number of cars/train. The result was shown in Table 7.

Table 7. Operating Headway for Karawang Airport in 2025

C_x = 4,370

p_x (cars/train)	N = 100 seats (100%) h_x (Headways; minutes)	N = 120 seats (120%) h_x (Headways; minutes)	N = 130 seats (130%) h_x (Headways; minutes)	N = 140 seats (140%) h_x (Headways; minutes)	N = 150 seats (150%) h_x (Headways; minutes)
1	1.11	1.33	1.45	1.56	1.67
2	2.22	2.67	2.89	3.11	3.34
3	3.34	4.00	4.34	4.67	5.00
4	4.45	5.34	5.78	6.23	6.67
5	5.56	6.67	7.23	7.78	8.34
6	6.67	8.01	8.67	9.34	10.01
7	7.78	9.34	10.12	10.90	11.68
8	8.90	10.68	11.56	12.45	13.34
9	10.01 *	12.01	13.01	14.01	15.01
10	11.12 *	13.34	14.46	15.57	16.68
11	12.23 *	14.68	15.90	17.12	18.35

Note: *) Possible range of headway (h_x) is in the range of 10-12 minutes with regard to the length of train of 9, 10, and 11 cars.

4.2.3 Simulation of operating headway for Majalengka Airport in 2019

Operating headway is simulated to the number of cars/train. The result was shown in Table 8.

Table 8. Operating Headway for Majalengka Airport in 2019

C_x = 98

p_x (cars/train)	N = 100 seats (100%) h_x (Headways; minutes)	N = 120 seats (120%) h_x (Headways; minutes)	N = 130 seats (130%) h_x (Headways; minutes)	N = 140 seats (140%) h_x (Headways; minutes)	N = 150 seats (150%) h_x (Headways; minutes)
1	49.75	59.70	64.67	69.65	74.62
2	99.50	119.40	129.35	139.30	149.25
3	149.25	179.10	194.02	208.95	223.87
4	199,00	238.80	258.70	278.60	298.50
5	248.75	298.50	323.37	348.24	373.12
6	298.50	358.19	388.04	417.89	447.74
7	348.24	417.89	452.72	487.54	522.37
8	397.99	477.59	517.39	557.19	596.99
9	447.74	537.29	582.07	626.84	671.61
10	497.49	596.99	646.74	696.49	746.24
11	547.24	656.69	711.41	766.14	820.86

Note: *) There is no possible range of headway (h_x) because there are few air passengers demand for Majalengka Airport. Therefore, Majalengka is unsuitable as a secondary Airport in MAS.

4.2.4 Simulation of operating headway for Majalengka Airport in 2025

Operating headway is simulated to the number of cars/train. The result was shown in Table 9.

Table 9. Operating Headway for Majalengka Airport in 2025

$C_x = 281$

p_x (cars/train)	N = 100 seats (100%) h_x (Headways; minutes)	N = 120 seats (120%) h_x (Headways; minutes)	N = 130 seats (130%) h_x (Headways; minutes)	N = 140 seats (140%) h_x (Headways; minutes)	N = 150 seats (150%) h_x (Headways; minutes)
1	17.29	20.75	22.48	24.20	25.93
2	34.58	41.49	44.95	48.41	51.87
3	51.87	62.24	67.43	72.61	77.80
4	69.15	82.99	89.90	96.82	103.73
5	86.44	103.73	112.38	121.02	129.66
6	103.73	124.48	134.85	145.22	155.60
7	121.02	145.22	157.33	169.43	181.53
8	138.31	165.97	179.80	193.63	207.46
9	155.60	186.72	202.28	217.84	233.40
10	172.89	207.46	224.75	242.04	259.33
11	190.17	228.21	247.23	266.24	285.26

Note: *) There is no possible range of headway (h_x) because there are few air passengers demand for Majalengka Airport. Therefore, Majalengka is unsuitable as a secondary Airport in MAS.

4.3 Review on the Maximum Theoretical Capacity

Data was given:

Safety factor in railway based transportation design regard to the brick-wall-stop (BWS) concept, K = 1,0-1,5.

Headway is determined:

min h_x = 10 minute = 600 second

max h_x = 15 minute = 900 second

Required maximum speed (V_o) = 80-100 km/h

Deceleration (d), assumed = 1-5 m/second^2 (3 m/second^2 is taken into account)

Station platform limit = maximum 11 cars per train

Length of train, L = 70 ft = 21.3 m

Capacity of car, N = 100 passengers

Calculated:

a. Speed at maximum capacity

V_o = speed at maximum capacity (km/h)

$$V_o = \sqrt{\frac{2pLd}{K}} \tag{5}$$

b. Minimum headway

h_m = minimum headway based on BWS concept (minute)

$$h_m = \sqrt{\frac{2pLK}{d}} \tag{6}$$

c. Maximum theoretical capacity

C_p = maximum theoretical capacity based on BWS concepts (passengers/hour)

$$C_p = 2546 \times N \times \sqrt{\frac{pd}{LK}} \tag{7}$$

4.4 The Feasible Operated Length of Train for Karawang Airport as Second Airport

The feasible number of cars per train (length of train) is simulated according to the requirements of a safe speed and headway (BWS concept). Demand considered is estimated demand (C_x) in 2019 and 2025. The results are shown in Table 10 and Table 11.

Table 10. Feasible number of cars per train according to a safe speed and headway for Karawang Airport in 2019

C_x = 2,912

Number of cars/train	Speed (km/h)	Time Headway, h_o (minutes)		Requirement	The maximum theoretical capacity
p_x	V_o	Calculated (h_x)	BWS (h_x)		(Pass/hour)
1	33.23	1.67	0.08		1,300
2	46.99	3.34	0.11		1,839
3	57.55	5.01	0.13		2,252
4	66.46	6.68	0.15	h_x (BWS) < min h_x (10 minutes)	2,601
5	74.30	8.34	0.17		2,907
6	81.40 *	10.01 *	0.19		3,185 *
7	87.92 *	11.68 *	0.20	min h_x = 10 minutes	3,440 *
8	93.99 *	13.35 *	0.22	max h_x = 15 minutes	3,678 *
9	99.69 *	15.02 *	0.23		3,901 *
10	105.08	16.69	0.24	V_o = 80-100 km / h	4,112
11	110.21	18.36	0.26		4,312

Note: *) speed at successive headway
**) successive headway
***) Maximum theoretical capacity at successive headway
The formula is adjusted regarding to the unit of d and L

Table 11. Feasible number of cars per train according to a safe speed and headway for Karawang Airport in 2025

C_x = 4,370

Number of cars/train	Speed (km/h)	Time Headway, h_o (minutes)		Requirement	The maximum theoretical capacity	Partial Double Decker
p_x	V_o	Calculated (h_x)	BWS (h_x)		(Pass/hour)	150%
1	33.23	1.11	0.08		1,300	1,950
2	46.99	2.22	0.11		1,839	2,758
3	57.55	3.34	0.13		2,252	3,378
4	66.46	4.45	0.15	hx (BWS) <min hx (6 minutes)	2,601	3,901
5	74.30	5.56	0.17		2,907	4,361
6	81.40 *	6.67	0.19		3,185	4,777
7	87.92 *	7.78	0.20	min hx = 6 minutes	3,440	5,160
8	93.99 *	8.90	0.22	max hx = 10 minutes	3,678	5,517
9	99.69 *	10.01	0.23		3,901	5,851
10	105.08	11.12	0.24	V_o = 80-100 km / h	4,112	6,168
11	110.21	12.23	0.26		4,312	6,469

From Table 10, it is obtained that:

1) The secondary airport, Karawang, is more feasible in the point of passengers than Majalengka (See Table 8 and Table 9)
2) The number of cars that feasible to be operated safely based on demand in 2019 is 6, 7, 8, or 9 cars per train. The provision of minimum headway is 10 minutes and the maximum headway is 15 minutes.
3) Maximum theoretical capacity during each successive headway is 3,185; 3,440; 3,678; or 3,901 passengers/hour

From Table 11, it is obtained that:

1) The feasible number of cars to be operated safely in 2025 is 6, 7, 8, or 9 cars per train in shorten headway (minimum of 6 minutes and maximum of 10 minutes).
2) Maximum theoretical capacity during each successive headway is 3,185, 3,440, 3,678, or 3,901 passengers/hour
3) As maximum theoretical capacity is less than the demand of 4,370 pass/hour, then the capacity is increased, for example by providing a partial double-decker that capacity by 150%. The result is that a maximum theoretical capacity increases. The capacity respectively are 4,777, 5,160, 5,517, or 5,851 passengers/hour
4) See Table 11, according to 8 cars/train, 10 minutes headway (frequency of 6 trains/hour), and partial double decker (150% seats), then the estimated line capacity is 6 x 8 x 100 x 150% x 1 = 7,200 passengers/hours.

5. CONCLUSION

The development of intermodal transport services in WJIA was directed to the mass transit service with high capacity and operating speed. The land public transport system used to support air passengers between Soekarno-Hatta International Airport (primary airport) and Karawang Airport (secondary airport) is express railway system (or rapid rail transit, RRT). According to the design criteria, such as 8 cars/train, 100 seats/car, 1 passenger/seat and with regard to the predicted number of passengers by 2019, the departure frequency required by 4 trains per hour or at headway of 15 minutes for Karawang Airport. The estimated line capacity in 2019 is 3,200 passengers/hour. In 2025, with regard to 8 cars/train, 10 minutes headway (frequency of 6 trains/hour), and partial double decker (150% seats), then the estimated line capacity is 7,200 passengers/hours.

In the point of air passengers, the Karawang Airport is more feasible as the secondary airport in MAS than Majalengka Airport. There is no possible range of headway (h_x) of operating the express railway system because there are few air passengers demand for Majalengka Airport. Therefore, Majalengka is unsuitable as a secondary Airport in MAS.

ACKNOWLEDGEMENTS

Thanks go to the Directorate Programs of Research and Community Services, Directorat General of Higher Education, Ministry of Education and Culture of Republic of Indonesia. Thanks also go to the Institute for Research and Community Service GMU regard to DIPA financial support for this study through the Higher Education for Fiscal Year 2013. Thanks are also due to all the support personnel and the research team of surveyors, for their cooperation in this study.

REFERENCES

Coordinating Ministry for Economic Affairs, 2011, *The Master Plan for the Acceleration and Expansion of Indonesian Economic Development*, 210 pages, Jakarta.

Decree of the Minister of Transportation, 2007, *Airport Master Plan in Majalengka*, KM 5 Year 2007 on Airport Master Plan in Majalengka district. West Java Province, Jakarta.

Decree of the Minister of Transportation, 2005, *Determination Airport Location in West Java*: KM 34 Year 2005 (changed to KP. 457 in 2012 about New Airport Location Determination in Kertajati municipal, Majalengka district, West Java Province), Jakarta.

Haryanto, I., Wiryanta, Suwardo, 2012, Determination of Second Airport to Soekarno-Hatta International Airport as a Multiple Airport System in Greater Jakarta: Karawang Airport or Majalengka Airport, *The Proceeding of 15th International Symposium FSTPT*, STTD Bekasi, November 23-25, Jakarta.

Haryanto, I., Wiryanta, Suwardo, 2012, Preparation of Model Interaction International Airport Soekarno-Hatta International Airport in West Java (Karawang and Majalengka): Competition and Centrality, *Final Report MP3EI*, Jakarta .

Khisty, C.J. and Lall, B.K., 2003, *Transportation Engineering : An Introduction*, 3rd Edition, Pearson Education, Inc. Upper Sadlle River, New Jersey 07458.

PT. MULTI Assens Nine Consortium, 2003, Feasibility Study on the International Airport Development in West Java: *Final Report*, Bandung.