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SIMULATION ANALYSIS OF INTERNATIONAL-DEPARTURE PASSENGER FLOWS IN AN AIRPORT TERMINAL

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ABSTRACT

An entire airport terminal building is simulated to examine passenger flows, especially international departures. First, times needed for passengers to be processed in the terminal building are examined. It is found that the waiting time for check-in accounts for more than 80 percent of the total waiting time of passengers spent in the airport. A special-purpose data-generator is designed and developed to create experimental data for executing a simulation. It is found that the possible number of passengers missing their flights could be drastically reduced by adding supporting staff to and by making use of first- and business-class check-in counters for processing economy- and group-class passengers.

1 INTRODUCTION

Airports or airport terminals are frequent topic areas for applying simulation. Recent research has reported on such topics as the check-in process, passenger flows in the terminals, vehicular traffic or road traffic on airport premises, and passenger boarding time.

Several studies have focused on the passengers who are processed at various stages in the airport terminal buildings. From among them, passenger flows and passenger boarding time are analyzed inside the airports (Gatersleben and Weij 1999; Hafizogullari, Chinnusamy and Tunasar 2002; Kyle 1998; Landeghem and Beuselinck 2002; Snowdon et al. 1998). In addition, the check-in processes are treated for analysis and reported (Chung and Sodeinde 2000; Joustra and Dijk 2001; Seneviratne and Martel 1995). The issues focused on airline schedules and delay are treated by using simulation (Hutchison and Hill 2001; Robinson and Stanger 1998; Schumacher 1999). Furthermore, a method of model building for the airport terminals is reported (Verbreaeck and Valentin 2002).

In this study, a simulation model of an entire airport terminal building is constructed and used to examine passenger flows, especially international departures. First, the time intervals spent at each stage for all passengers of international departure are examined; where the passengers wait for available counters or booths, where they are processed, passenger moves, or kill time. Then, the waiting time for available check-in counters is examined. Preliminary simulation experiments indicated that when more passengers than usual are to be processed at the terminal, it becomes difficult to process the designated number of passengers to meet their boarding times. Then, possible methods to assure more passengers catch their flights are examined, especially for the selected airline company. Hence, in order to create experimental data to execute simulation, a special-purpose data-generator is designed and developed. The experimental data to be created includes time of the departure, number of passengers for each class, and so on, based on the actual data. Through a series of simulation experiments, several methods for reducing the number of possible passengers missing their flights are examined.

2 THE BOARDING PROCESS OF INTERNATIONAL DEPARTURES

Kansai International Airport in Japan has spaces for processing international departure on both the third and fourth floors of the terminal building. Overall layouts of the fourth floor and the third floor are shown in Figures 1 and 2, respectively. Passengers arrive to the fourth floor first, and then proceed to receive a series of all required processes on that floor. Passengers arriving from abroad are routed to the lower and separated levels of the floors. The places where those processes are conducted include travel-agent counters, baggage security-check booths, check-in counters of the designated airline companies, PSFC (i.e., the charge for using the airport facilities) ticket-vending machines, PSFC gates, and the security check gates at X-ray. On third floor, there are departure-formalities count-

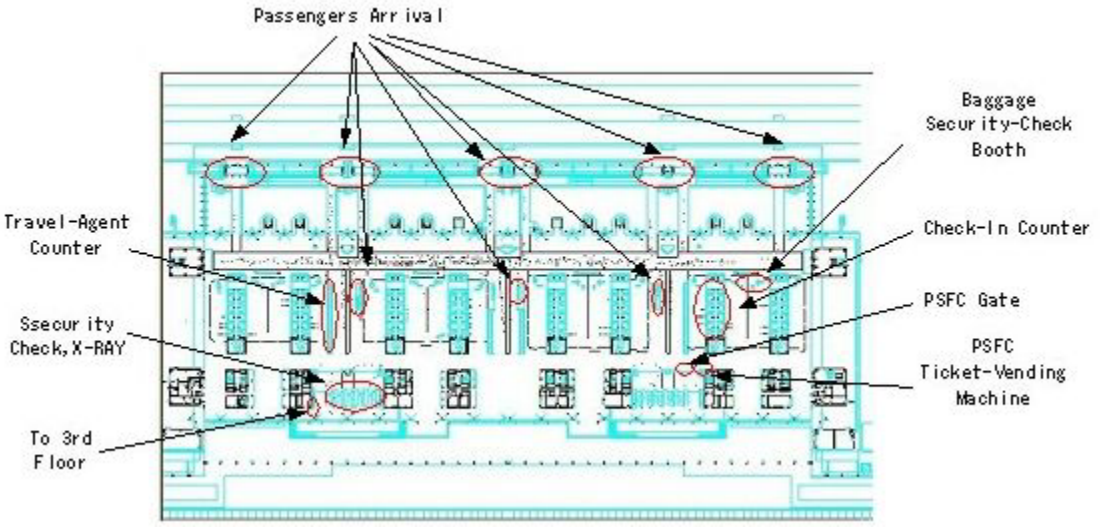

Figure 1: Overall Layout of 4th Floor of Kansai International Airport

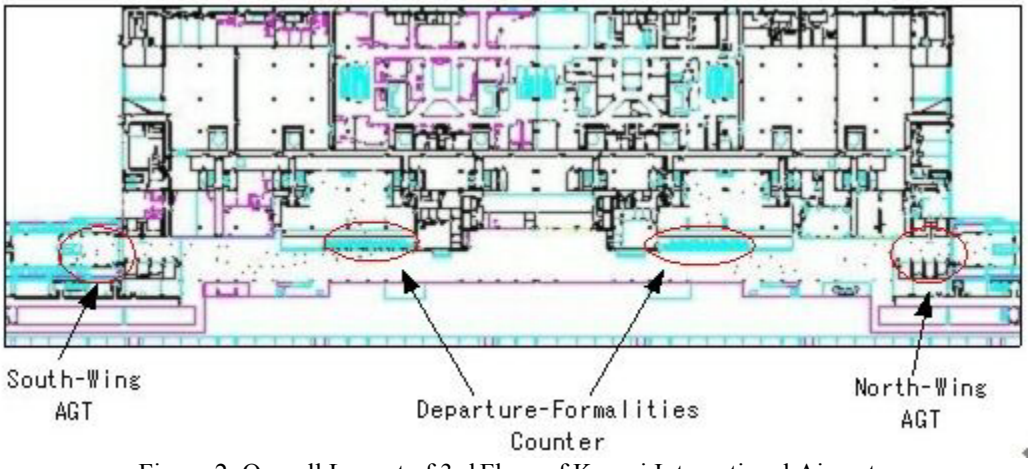

Figure 2: Overall Layout of 3rd Floor of Kansai International Airport

ers to examine passengers' passports. After finishing all required procedures, the passenger gets on an AGT (i.e., a monorail) that is connected to either the north or south international boarding gate areas. Passenger flows of international departure are illustrated in Figure 3.

3 PRELIMINARY ANALYSIS OF THE BOARDING PROCESS

In this section, all associated areas of the airport terminal building are included in a simulation model that is used to examine passenger flows, especially the international departures. The simulation programs were written in Arena (Kelton, Sadowski, and Sadowski 2001).

Experimental conditions of passengers are summarized in Table 1. In this table, the number of passengers per flight, passenger types on Japanese/aliens, individuals/group, classes, velocity of passengers' walking, and cart/baggage/no baggage are shown. In addition, data on facilities of the airport terminal (travel-agent counters, baggage security-check booths, check-in counters of the designated airline companies, PSFC ticket-vending machines, PSFC gates, security check gates by X-ray, and departure-formalities counters) are summarized in Table 2.

First, the amount of time at each stage where the passengers wait for available counters or booths, where they are to be processed, when they move, or kill time are examined for all international departure passengers. Times spent in the terminal building and passenger waiting times are summarized in Figures 4 and 5 respectively, and are from preliminary simulation experiments. Of the total time spent in the terminal building, 48 percent was spent traveling from one place to another, 25 percent was waiting time, and 4 percent was spent in formalities at such places as check-in counters and departure-formalities counters. In addition, it is found that the waiting time for available

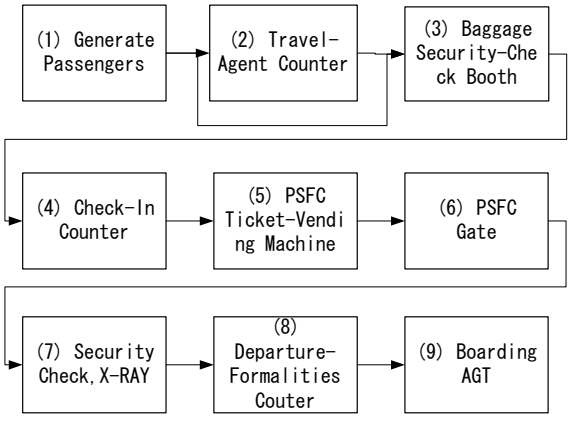

Figure 3: Flow of Passengers

Table 1: Experimental Conditions

	Item	Description		Unit	Normal	Crowded
1	Passengers on Board	JB	B742	(Person/Flight)	360	400
			B744		420	
			B74D		560	
		AB	A330		250	300
			A340		280	
			B772		320	
			B773		380	
			DC10		210	
			MD11		250	
		MJ	B762		180	200
			B763		210	
			B757		180	
			A306		270	
			A310		210	
			A320		150	
			B734		120	
			B738		150	
2	Japanese/Alien	Japanese		(%)	80	80
		Alien			20	20
3	Grouped Passengers	G	Group	(%)	55	55
4	Classes	F	First	(%)	1	1
		C	Business		9	9
		Y	Economy		35	35
5	Boarding Rate			(%)	70	80
6	No. of pcs. ofBaggage			(pcs./Flight)	0.89	0.89
7	Passenger Velocity			(m/min.)	60	60
8	Passengers Types	Staying When Created		(%)		
		Waiting at Travel-Agent Counters			Cart35% Baggege65%	
		Waiting at Baggage Security-Check				
		Waiting at Check-In Counter			Baggage100%	
		Waiting at PSFC Ticket-Vending Machine			No Baggage	
		Waiting at Security Check,XRAY			No Baggage	
		Waiting at Departure-Formalities			No Baggage	

Table 2: Data on Facilities of Airport Terminal

Facilities	No. of Counters (conters)	Processing Time (sec./person)
Travel-Agent Counter	48	90
Baggage Security-Check Booth	8	10
Check-In Counter	135	F,C: 170 Y:150, G: 90
PSFC Ticket-Vending Machine	12	10
PSFC Gate	4	0
Security Check, X-RAY	8	Normal: 7, Pick Up:37
Departure Formalities	26	Japanese:10, Alien:25

(Note F: First, C: Business, Y: Economy, G: Group)

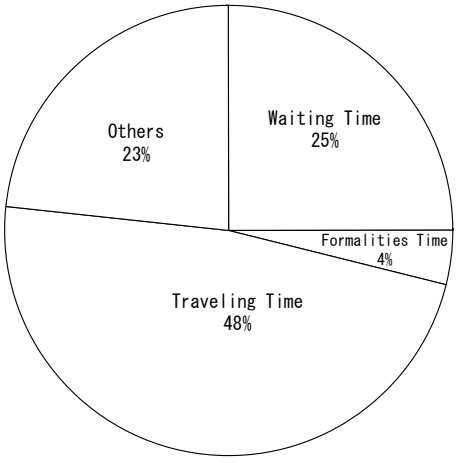

Figure 4: Time Spent in Terminal Building

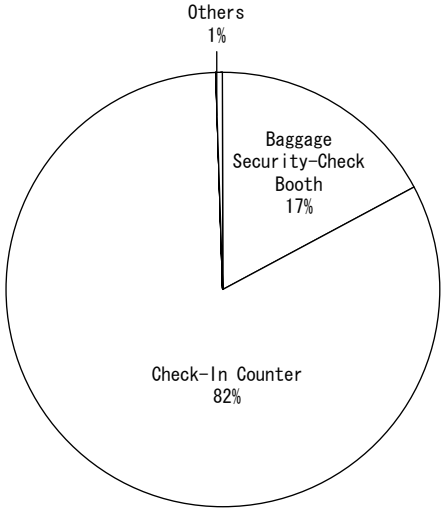

Figure 5: Waiting Time

check-in counters accounts for more than 80 percents of all waiting time.

4 DATA GENATOR FOR SIMULATION

In the case where more passengers than usual are to be processed at the terminal, it would be difficult to process all passengers to meet their boarding times. From the result of preliminary simulation experiments, the check-in process is expected to be the bottleneck, as mentioned in the previous section. Hence, in order to examine more congested situations, a special-purpose data-generator is designed and developed to create experimental data. This data generator is written in Excel VBA. Experimental data created contain time of departure, number of passengers for each class, and etc.

The overall flow of the data generator proposed in this study is shown in Figure 6. A similar idea for the data generator for simulation experiments appears in simulation of warehousing at distribution centers for creating data on incoming and outgoing trucks (Takakuwa, Takizawa, and Ito 2000). The required input parameters are the number of flights and the percentage of passengers on board to the boarding capacity of the associated aircraft (the boarding rate), as shown in Figure 7. By inputting these two parameters, the corresponding flight schedule would be created. Table 3 shows a sample output created by the proposed data generator. The generated data includes the departure time and the number of passengers for each class.

By making use of this generated data as an external file input for the simulation model, experiments can be conducted under any specified condition.

5 SIMULATION ANALYSIS

First, the utilization of the check-in counters and the number of waiting passengers at the check-in counters are examined by varying the number of flights and the boarding rate. These figures were selected, considering the degree of the congestion. The normal congestion condition is based on the flight operations for a regular operating day, that is, the number of flights is 100 and the boarding ratio is 70 percent. A specific airline company which we will call 'A Company' is selected to be analyzed, as shown in Figure 8. Twenty-five percent of all flights are on this airline company. The actual number of passengers will be determined by the combination of the number of flights and the associated boarding rate. Additional experimental conditions to be modified were given in Table 1 for the preliminary analysis and are shown in Table 4. In this ta-

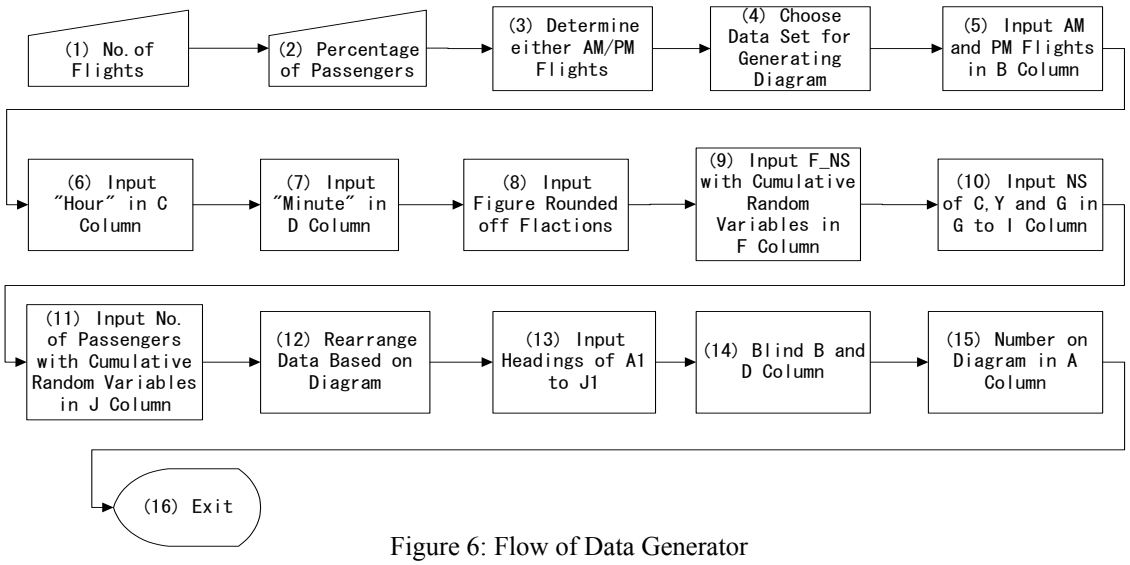

Figure 6: Flow of Data Generator

(a) Specifying the Number of Flights (b) Specifying Percentage of Passengers on Board

Figure 7: Inputting Parameters

Table 3: Sample of Generated Data

No	Hour	Minute	Accumulated Time	Starting Time	Time Interval	F_NS	C_NS	Y_NS	G_NS	No.of Passengers	F_No.of Passengers	C_No.of Passengers	Y_No.of Passengers	G_No.of Passengers
1	9	10	33000	18600	18600	10	27	44	61	126	1	11	44	70
2	9	25	33900	19500	900	8	25	42	60	294	3	26	103	162
3	9	40	34800	20400	900	6	23	40	56	146	1	13	51	81
(Omitted)														
98	22	55	82500	68100	0	8	25	42	60	146	1	13	51	81
99	23	5	83100	68700	600	6	23	40	56	146	1	13	51	81
100	23	15	83700	69300	600	8	25	42	60	104	1	9	36	58

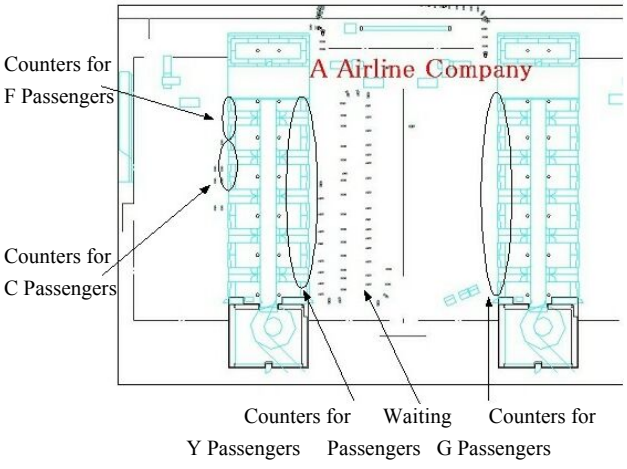

Figure 8: Check-In Counter of A Airline Company

Table 4: Additional Data on Facilities

Check-In Counter	No. of Counters (counters)	Processing Time together with Supporting Staff (sec./person)
First Class (F)	2	-
Business Class (C)	3	-
Economy Class (Y)	9	100
Group Class (G)	12	60

ble, the processing time at the check-in counters with the aid of the supporting staff would be reduced to two thirds of the time performed by only the regular staff. In addition, the numbers of check-in counters for the first, business, economy and group classes of A airline company are indicated, respectively.

The results for the utilization of the check-in counters and ratio of waiting passengers are summarized with respected to the number of flights in Figures 9 and 10, respectively. The number of replications for each experiment is ten, and the means of the results obtained by performing ten replications are indicated in these figures. As the number of flights per day increases, the utilization increases. In addition, the number of waiting passengers at the check-in counters increases, and the utilization for each check-in counter becomes almost one hundred percent as the number of flights increase. This means that some passengers would miss their flights, unless some additional means are introduced for check-in counter operations.

To explore the issue of passengers missing their flights, let us assume that passengers would miss their

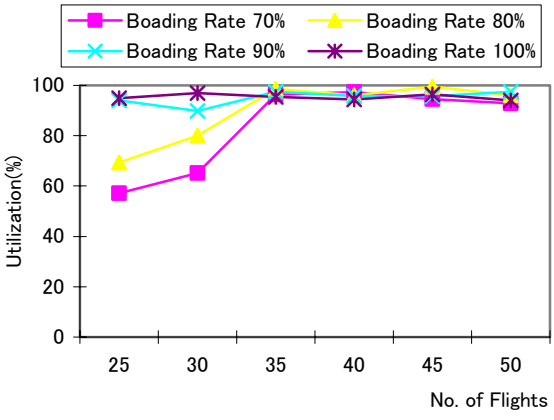

Figure 9: Utilization (A Company/Y Counter)

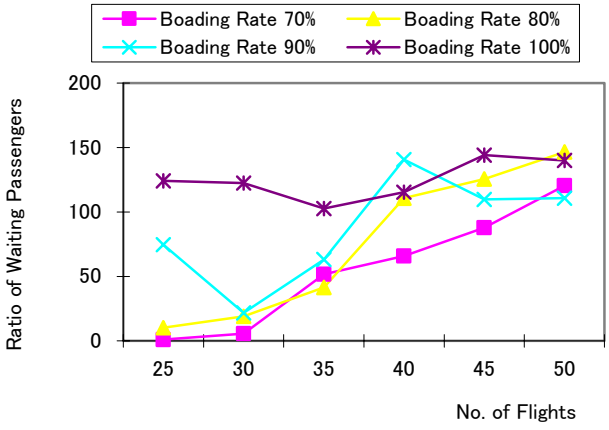

Figure10: Waiting Passengers (A Company/Y Counter)

flights if they do not get on an AGT for the designated (i.e., north or south) boarding gates at least ten minutes before their departure times of their flights. In addition, it is assumed that they would not hurry for boarding even though they might be missing their flights. The relationship between the congestion and passengers missing flights is shown in Figure 11. From this figure, it is found that passengers would miss their flights a couple of hours later than the corresponding peaks of the congestion (crowdedness) at the check-in counters.

Then, the possible methods to assure more passengers catch their flights are examined to overcome these difficulties, especially for the selected airline company (A Company). In this study, two ways are examined: (1) adding supporting staff to the regular staff, and (2) making use of first- and business-class check-in counters for processing economy- and group-class passengers. Simulation experiments are executed under four conditions with the combination of these two methods, by varying the number of boarding passengers. Ten runs are performed for each scenario. The results are shown in Figure 12. From the results of simulation experiments, it is found that the number of potential passengers missing flights could be drastically reduced by adding

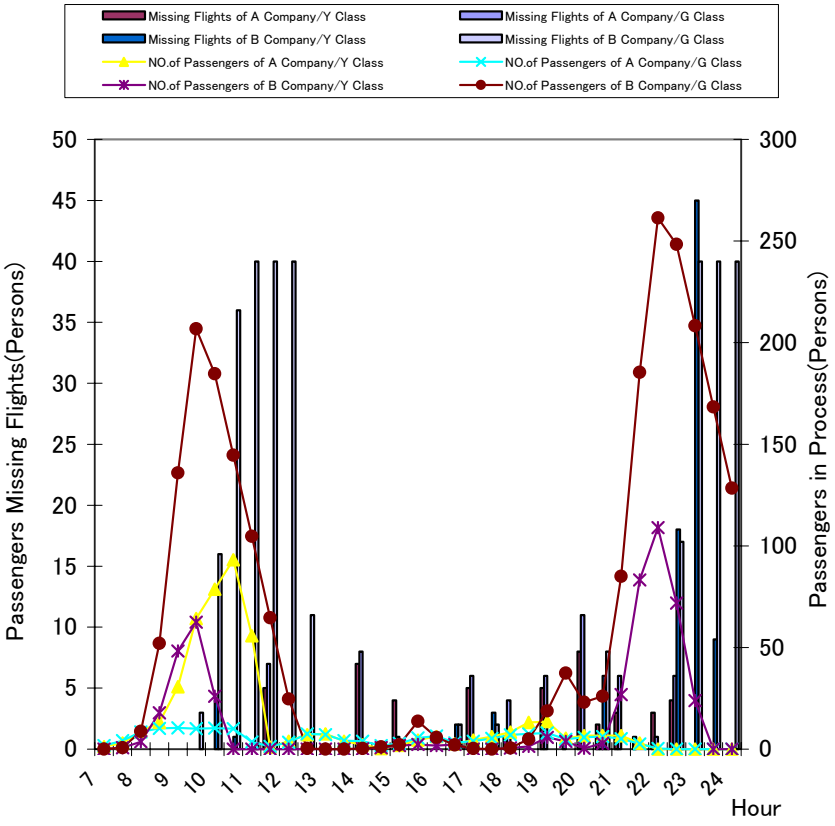

Figure 11: Congestion and Missing Flights

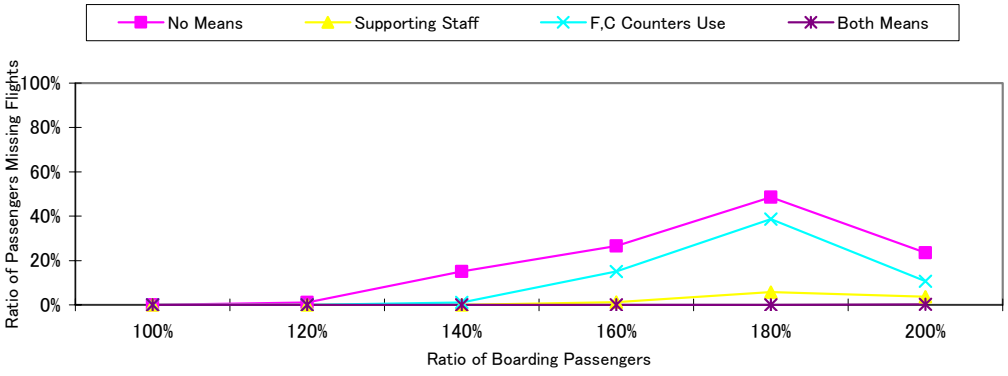

Figure 12: Ratio of Passengers Missing Flights and Ratio of Boarding Passengers

supporting staff to the regular staff and by making use of first- and business-class check-in counters for processing economy- and group-class passengers.

6 CONCLUSIONS

1. A simulation model of the airport terminal building is constructed and used to examine passenger flows, especially international departures.
2. The passengers spend 25 percent of their time waiting (of the total time spent in terminal building since their arrivals to the airport.) In addition, it is found that the waiting time for available check-in counters accounts for more than 80 percent of all the waiting time in the airport terminal building.
3. A special-purpose data-generator is designed and produced in order to create experimental data to execute simulation experiments under the various conditions of congestion.
4. It is found that the number of passengers missing flights can be drastically reduced by adding supporting staff to the regular staff and by making use of first- and business-class check-in counters for processing economy- and group-class passengers.

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