Assignment 8: Capacity and Demand Estimation

Date Due: April 21, 2014 (via email)
Instructor: Trani

Problem 1

An airport shown in Figure 1 is to be studied for capacity analysis. The airport has a standard airport surveillance radar (ASR) which tracks aircraft up to 60 nautical miles form the airport site. The radar has a scan rate of 4 seconds. Tables 1 and 2 show the typical ATC separations at the airport under IMC conditions. Assume the minimum separations under VMC conditions are reduced by 10% from those observed under IMC conditions. All five aircraft groups operate at the airport. The airport has the following technical parameters: a) in-trail delivery error of 14 seconds (because there is a radar at the site), b) departure-arrival separation for both VMC and IMC conditions is 2 nautical miles, c) probability of violation is 5%. Arriving aircraft are "vectored" by ATC to the final approach fix located 10 miles from the runway threshold. Arrivals follow in-trail after crossing the final approach fix. The airport aircraft mix, runway occupancy times and approach speeds are shown in Figure 2.

. Show me a few sample calculations for both opening and closing cases.

a) Calculate the arrival-departure saturation capacity diagram (Pareto diagram) under IMC conditions (show all your work). In your diagram, include at least one point to estimate the departure capacity with 100% arrival priority under mixed runway operations. Show me sample calculations of Tij and Bij so that I can judge your analysis.

b) Repeat part (a) for VMC conditions. Assume departure-departure headways are also reduced by 10% in VMC conditions. Comment on the differences observed. Specifically, comment on the number of departure values obtained with 100% arrivals. Show me sample calculations of Tij and Bij so that I can judge your analysis.

Table 1. Minimum arrival-arrival separations under IMC conditions. Values in are nautical miles. Values Shown Do Not Include Buffers.

Minimum Separation Matrix (nm)			Arrivals-Arrivals		
		Trailing Aircraft (Header Columns)			
Lead (column 1)	Small	Large	B757	Heavy	Superheavy
Small	3	3	3	3	3
Large	4	3	3	3	3
B757	5	4	3	3	3
Heavy	6	5	4	3	3
Superheavy	8	8	8	8	8

Table 2. Minimum departure-departure separations under IMC conditions. Values in are seconds.

Departure-Departure Separation Matrix (seconds)					
		Trailing Aircraft (Header Columns)			
Lead (column 1)	Small	Large	B757	Heavy	Superheavy
Small	60	60	60	60	60
Large	90	60	60	60	60
B757	120	120	60	60	60
Heavy	120	120	120	120	90
Superheavy	150	120	120	120	120

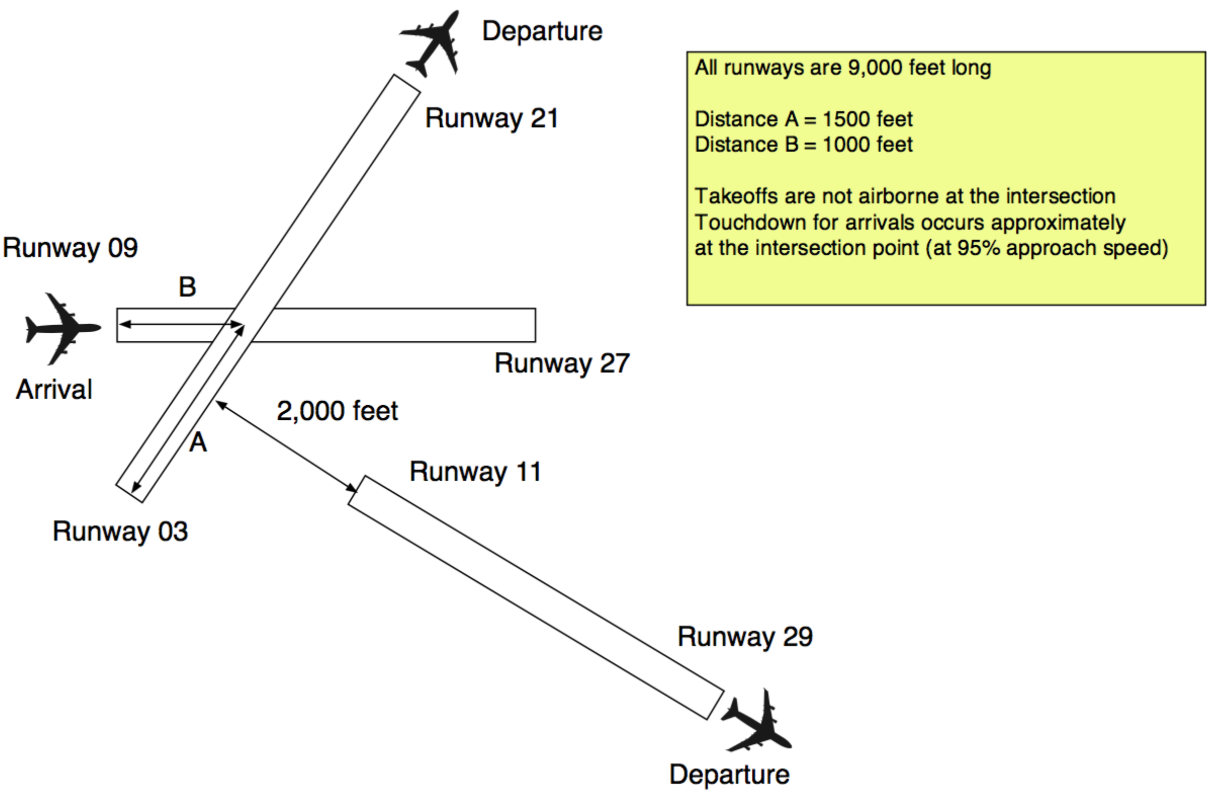

Figure 1. Diagram for Airport of Problem 1.

	Small	Large	B757	Heavy	Superheavy
ROT (s)	48	51	60	65	75
Percent Mix (%)	10	55	10	20	5
Vapproach (knots)	120	140	142	155	150

Figure 2. Airport Arrival Occupancy Times and Fleet Mix for Problem 1.

A few operational rules apply to this airport:

1) Assume a typical acceleration rate on the runway of 2.5 m/s-s for takeoffs.

2) Assume a typical deceleration rate after touchdown of -2.3 m/s-s.

3) All landings on runway 09 occur after the intersection point.

4) Takeoffs on 03 are allowed as long as there is an arrival on 09 that is >=2.0 nm from the threshold 09.

5) Takeoffs on 09R or 14 are allowed as soon as another takeoff has crossed the runway intersection (no wake vortex effect as the aircraft are on the ground).

6) Takeoffs on03 are allowed as soon as an arrival on 09 has crossed the runway intersection (no wake vortex effect as the aircraft are on or very close to the ground). Allow the standard 10 second time lag for ATC to clear the departing aircraft on runway 03.

Problem 2

Familiarize yourself with the passenger data presented below for Cheju International Airport in South Korea. The passenger data has been collected from Wikipedia (http://en.wikipedia.org/wiki/Jeju_International_Airport).

a) The airport has 14 gate positions to service aircraft at the terminal (includes 4 ramp positions). Assume that the ultimate passenger capacity of the existing airport is 29 million passengers per year. Estimate the best parameters of a Logistic forecast demand model for this airport. Use Excel solver in your analysis.
b) Comment on the goodness of fit of the proposed Logistic model.

Table 3. Cheju International Airport Passenger Demand.

Year	Passengers
1997	9,819,129
1998	7,469,980
1999	8,242,134
2000	9,125,939
2001	9,320,337
2002	9,939,700
2003	10,802,989
2004	11,104,341
2005	11,354,925
2006	12,109,836
2007	12,296,426
2008	12,448,084
2009	13,643,366
2010	15,724,360
2011	17,201,878
2012	18,443,047
2013	20,055,238

Problem 3

Before building its seventh runway, the Dallas-Forth Worth Airport had a departure saturation capacity of 23 departures per 15-minute period (see red line in Figure 3). The airport is a major hub for American Airlines and back in 2001 had a departure demand as shown in Figure 32. The departure saturation capacity has been estimated using two fully independent runways for departures.

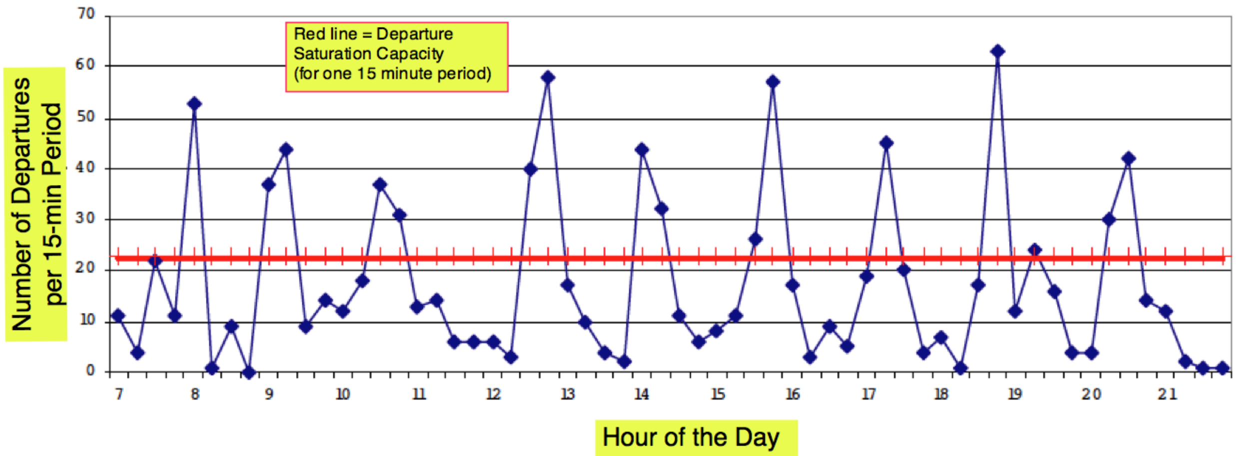

Figure 3. IMC Departure Saturation Capacity (red line) and Scheduled Departure Profile for DFW Airport. Source: FAA Airport Capacity Benchmarks.

a) Convert the graph shown to numerical values of departure demand over time.

b) Estimate the aircraft departure queues that were likely to be experienced before the 7th runway was built.

c) Estimate the average delay per departure at DFW using the unsteady queueing model.

d) Suppose that after adding the 7th runway was constructed, the departure capacity increased by another 35 departures per hour (in IMC conditions). Estimate the new delays at the airport. Assume the demand function remained the same. Was the additional runway justified?

e) Estimate the total delay reductions due to the 7th runway.