Assignment 9: Airside Queueing Applications
Part 1 of Final Project

Date Due: April 23, 2015
Instructor: Trani

Problem 1

Before embarking on a very expensive and ambitious runway reconfiguration project (see Figure 2), the Chicago O'Hare International Airport had a departure saturation capacity of 25 departures per 15-minute period (see red line in Figure 1). The airport is a major hub for United and American Airlines and back in 2001—2004 had a departure demand as shown in the blue line of Figure 1. The departure saturation capacity has been estimated using 2 independent runways for departures.
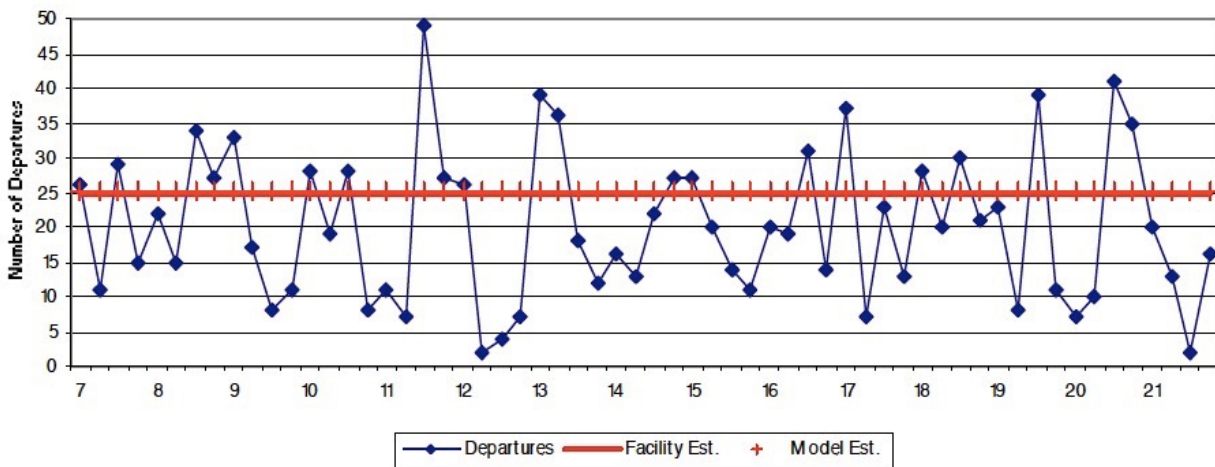

Figure 1. IMC Departure Saturation Capacity (red line) and Scheduled Departure Profile for ORD Airport. Source: FAA Airport Capacity Benchmarks (2004).

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 for the conditions shown in Figure 1.

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

d) Suppose that after the reconfiguration, the departure capacity per hour increased to 140 departures per hour using 3 independent runways . Estimate the new delays at the airport. Assume the demand function remained the same. Was the additional runway needed?

Problem 2

a) Calculate the annual benefits of the reconfiguration project at ORD in terms of departure delay savings. Assume the average cost of one hour of delay to the airlines at DFW is $2,900 per hour per aircraft. Also consider the value of time for passengers. According to FAA/DOT data, the value of time for a passenger traveling long distance is $32/hr. The average seating capacity of aircraft operating at ORD is 115 seats and the average load factor for airlines using ORD is 79%.

b) An estimated cost of reconfiguring the runways at ORD is $3400 million dollars. Use your knowledge of engineering economics to explain how would you do an economic analysis for the new runway investment. The construction of the runway

was funded through bonds at an interest rate of 4% per year. Hint: Review the use of Net Present Value or Benefit/Cost ratio techniques.
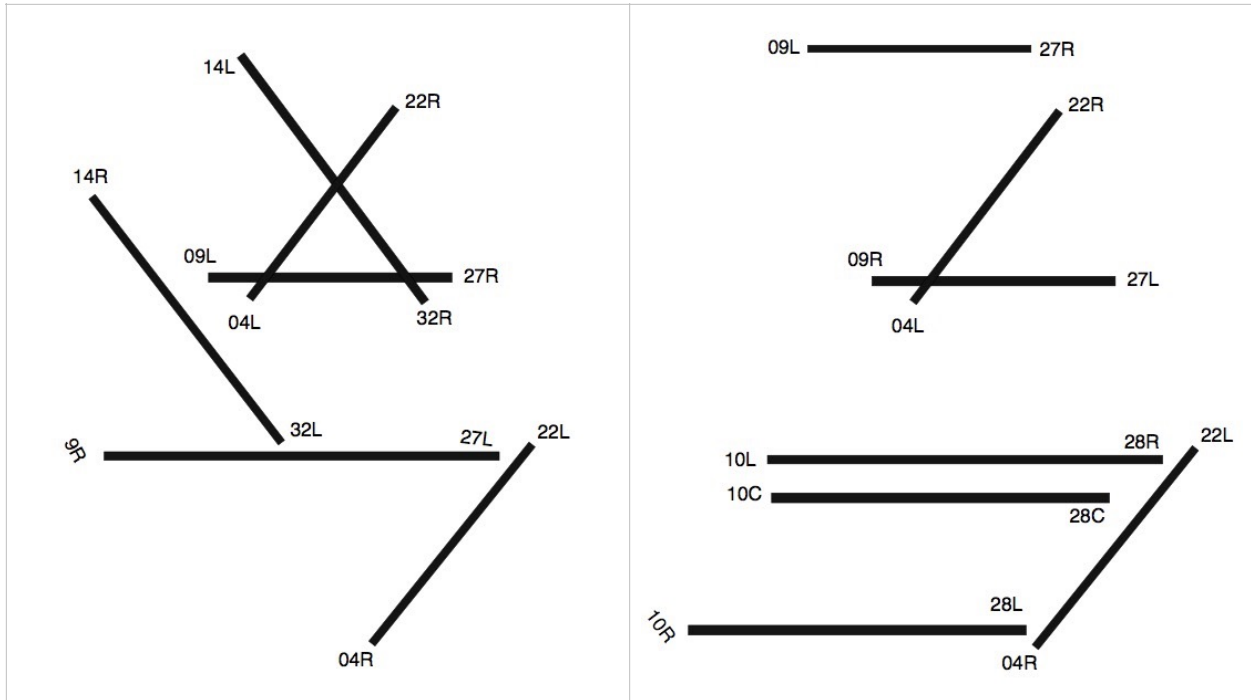

Figure 2. ORD Airport Layouts. Left-Hand side is the Original Runway Configuration. Right-hand Side is the Reconfigured Airfield.

Part 2 of Final Project (Groups of 2 people)
Due: May 8, 2015 (Final Exam Time)
Requirements for this Miniproject: a) Slide presentation and b) 8-10 page report with your findings.

Problem 1

Table 1 illustrates the typical aircraft fleet mix operating at ORD Airport in the typical day. This aircraft mix will be used to estimate the noise contours and the capacity of the airport. In the typical day of the year 2014, the airport handled **2,640 operations daily**. Half of them arrivals and the other half departures. Recent airport data suggests 110 departures and 110 arrivals occur at night between 10 PM and 7:00 AM in the morning. The simplified fleet mix operating at the airport is shown in Table 1. The table also shows the average stage length (miles flown) by each departure.

Table 1. ORD Fleet Mix and INM Aircraft to be Used in the Study.

Aircraft	% Fleet Mix in 2014	INM Aircraft to Use	Wake Class	Average Stage Length Flown (statute miles)
Embraer 145	35	E145	Large	335
B737 (600-900)	11	737700	Large	1260
747-8/A380	4	747400	Super-heavy	5200
B767	5	767CF6	Heavy	3656
A320 (318-321)	10	A320-232	Large	1170
CRJ (200-900)	28	CL601	Large	359
B777 (200-300)	7	777300	Heavy	6534
Total	100			

Using the arrival-arrival and departure-departure separation matrices shown in Tables 2 and 3, determine the saturation capacity of the airport for West Flow operations. Assume the ROT values at the airport for 4 wake classes are: 52 (small), 56 (large), 63 (Heavy) and 83 (Superheavy) seconds. For both IFR and VFR conditions, the airport operates arrivals and departures as shown in Figure 1. The approach speeds (in knots) derived from radar data are: 127 (small), 138 (large), 152 (Heavy) and 152 (Superheavy). The airport has the following technical parameters: a) in-trail delivery error of 14 seconds, 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 7 miles from the runway threshold.

Table 2. Arrival-Arrival Separation Matrix. VFR Conditions.

Minimum Separation Matrix (nm)	Arrivals-Arrivals				
	Trailing Aircraft (Header Columns)				
Lead (column 1)	Small	Large	B757	Heavy	Superheavy
Small	2.5	2.5	2.5	2.5	2.5
Large	4	3	2.5	2.5	2.5
B757	5	4	3	3	2.5
Heavy	6	5	4	4	4
Superheavy	10	10	10	10	10

Table 3. Departure-Departure Separation Matrix. VFR Conditions.

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

    a) **Plot the complete Pareto capacity diagram for VFR conditions at the airport. Label appropriately.**

Problem 2

Perform a noise study for the ORD airport considering the fleet mix shown presented in Table 1. The arrival and departure flow patterns are shown in Figure 1. Assume that the distribution of arrivals is that shown in Figure 1. The words PA stand for Percent Arrivals and PD for percent departures. Assign aircraft classes randomly the arrival and departure streams. Consider the number of arrivals and departures performed during the day and night time as described in the previous section.
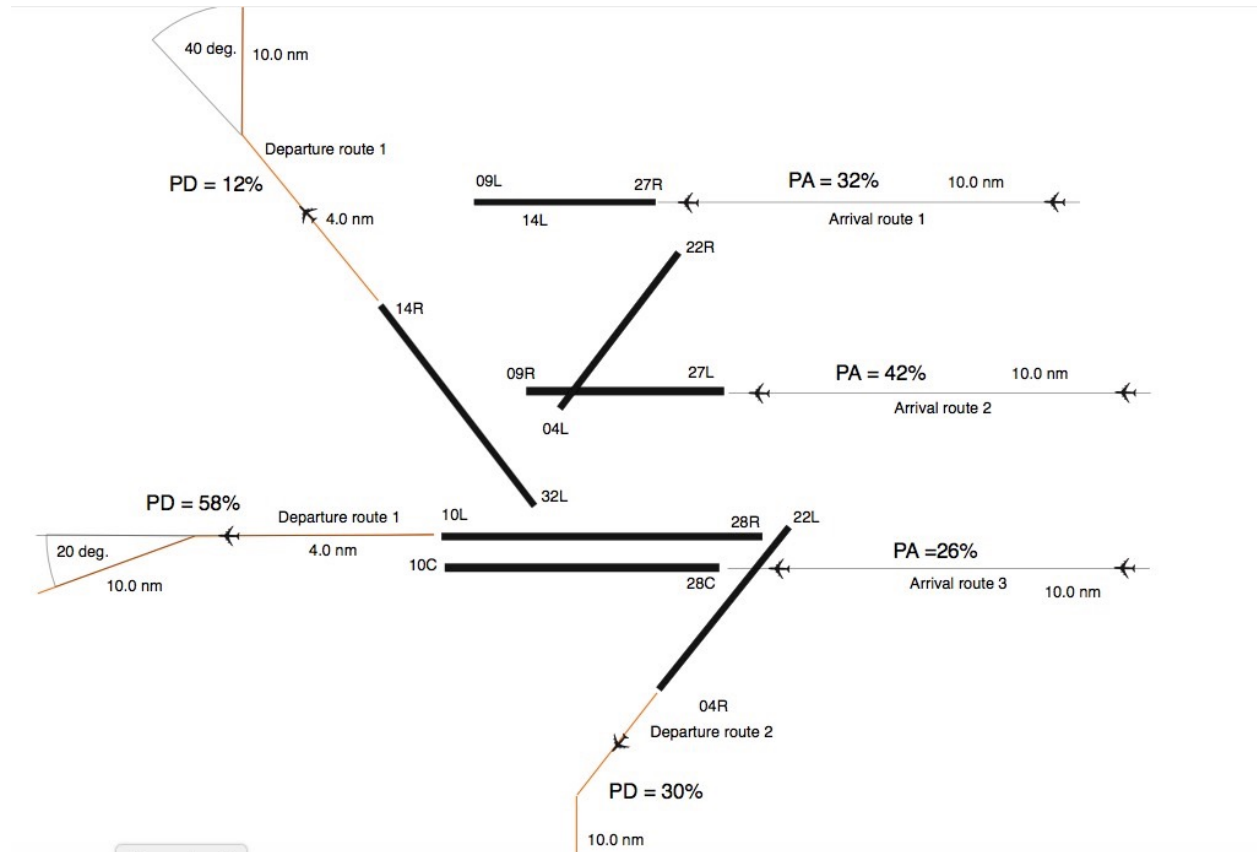

Figure 1. Simplified Arrival and Departure Patterns to ORD.

a) Find the noise contours around the airport from 55-80 LDN. Plot using your CAD and INM skills. Export the noise contours to a DXF file and then read the file using Autocad or equivalent application.

b) Estimate the area under the 55 and 65 LDN contours.

c) Suggest improvements to reduce the noise at this airport.

Bonus: Export the contours to Google Earth and superimpose the contours exported as an Image Overlay (or layer) of the Google Earth satellite picture.