Assignment 8: Runway Capacity and Delay Analysis

Date Due: November 9, 2015 Instructor: Trani

Problem 1

Consider the runway saturation capacity under IMC weather conditions for Ronald Reagan Airport (DCA) as shown in Figure 1. The diagram is available at: https://www.faa.gov/airports/planning_capacity/profiles/media/DCA-Airport-Capacity-Profile-2014.pdf. The assumption in the analysis shown in Figure 1 is that runway 1 is used for both arrivals and departures in IMC conditions.

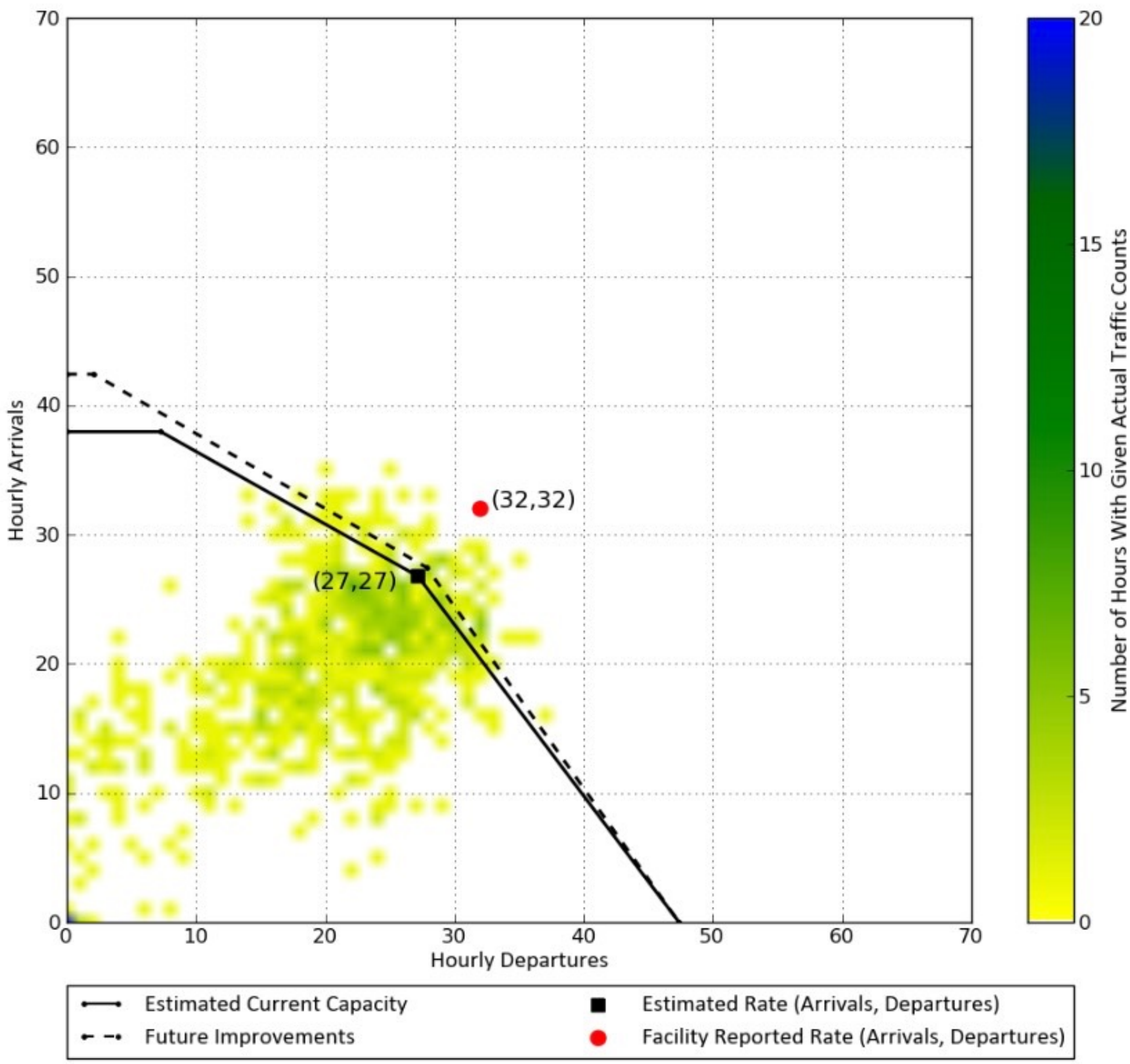

Figure 1. Pareto Diagram for DCA Airport (source: FAA, 2014).

a) Estimate the **average delays to both arrivals and departures** at the airport if the daily demand function is as shown in Table 1. Explain where in the Pareto diagram should the Air Traffic Control manager operate the airport in various hours of the day. Consider that for practical purposes, that the maximum number of operating points along the Pareto boundary that can be operated daily is 4.

b) Estimate the maximum number of aircraft waiting for departure at the departure queue of the runway during the busy period.

c) The dotted line in Figure 1 shows future improvements to this airport from various NextGen initiatives. Will there be relief to delays if these changes are implemented?

d) Observe that the ATC control tower reports a maximum arrival and departure rate of 32/32 per hours. Look at the configuration of DCA and provide some insight on what the reported rates are far better than the Pareto diagram shown in this figure

Table 1. Flight Demand for Problem 1.

Time Period	Arrival/hr	Departures /hr
0-4	3	5
4-6	12	10
6-7	28	25
7-8	32	30
8-9	30	28
9-10	24	25
10-11	18	16
11-12	20	23
12-13	17	12
13-16	20	16
16-18	20	14
18-19	27	29
19-20	30	19
20-21	28	27
21-22	18	21
22-24	5	4

Problem 2

Data is collected at an airport for two aircraft groups is shown in Table 2.

Table 2. Observed Normal Distributions for Two Aircraft in the Fleet Mix. Values in parenthesis are the mean and the standard deviation of each parameter.

Parameter	Aircraft Group 1 Distribution	Aircraft Group 2 Distribution
Touchdown distance (m)	*dt*=(265,98)	dt=(213,90)
Approach speed (m/s)	Vapp = (64.2,3.7)	Vapp = (55,3.1)
Free roll time (seconds)	tr = (1.5,0.5)	tr = (1.6, 0.40)
Deceleration rate (m/s-s)	aMean[1] = (2.3,0.3)	aMean = (2.4,0.29)
Exit Speed (m/s)	Vexit = (10.1,2.6)	Vexit = (9.2, 2.3)
Turnoff time (s)	toff = (9.6,2.25)	toff = (10.1, 2.8)

1 - deceleration rate is negative in the equations presented in the class notes but here we show the values as positive.

a) Using Matlab or Excel (your choice) and the kinematic equations of motion shown in the class notes (http://128.173.204.63/courses/cee5614/cee5614_pub/FAA_modeling_and_sim.pdf) and the distributions shown above, estimate the "natural distribution" of runway occupancy times (ROT) and landing distances for the complete population of aircraft. Assume that aircraft 1 represents 70% of the population operating at the airport (i.e., only two aircraft operating at the airport). The equations are reproduced in Table 3.

Table 3. Kinematic Equations of the Aircraft Landing Process.

Parameter	Mathematical Expression
Air distance (m)	$S_{air} = d_t$
Air time (s)	$t_{air} = 2S_{air}/(V_{app} + 0.95V_{app})$
Free roll distance (m)	$S_{fr1} = t_r(0.95V_{app})$
Braking distance (m)	$S_{brake} = \left[(0.95V_{app})^2 - (V_{exit})^2\right]/-2a_d$
Braking time (s)	$t_{brake} = (0.95V_{app} - V_{exit})/(-a_d)$
Total distance (m)	$S_{total} = S_{air} + S_{fr1} + S_{brake}$
Runway occup. time (s)	$t_{total} = t_{air} + t_r + t_{brake} + t_{turn}$

b) Plot a histogram of the natural distribution of landing distances. Repeat for ROT times.

c) Where would you locate 3 runway exits if the airport has a single runway? State the distances from the threshold of your suggested runway exits.