Assignment 8: Airport Capacity and Airport Demand

Date Due: April 17, 2017
Instructor: Trani

Problem 1

The Ronald Reagan National Airport has the configuration shown in Figure 1.

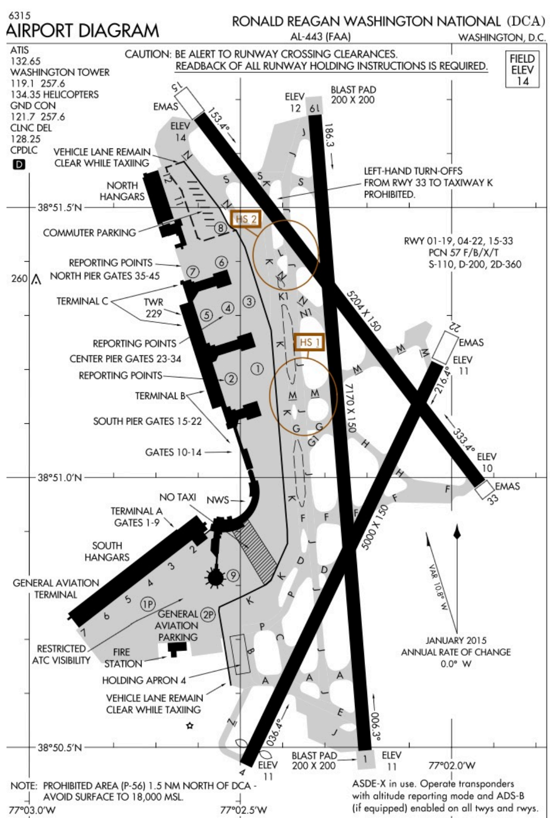

Figure 1. Configuration of DCA Airport. Runway 19 used for Arrivals and Departures.

The operating runway is 19 for both arrivals and departures. The airport has a standard airport surveillance radar (ASR) which tracks aircraft up to 50 nautical miles form the airport site. The radar has a scan rate of 4.0 seconds. Table 1 shows some of the technical parameters of the airport. Tables 2 and 3 show the estimated ATC separations at the airport under VMC conditions. Four aircraft groups operate at the airport as shown in Table 1. The airport has the following technical parameters: a) in-trail delivery error of 15 seconds (because there is a radar at the site), b) departure-arrival separation for both VMC and IMC conditions is 2.2 **nautical miles**, c) probability of violation is 5%. Arriving aircraft are "vectored" by ATC to the final approach fix located 9 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 Table 1.

You are allowed to modify the spreadsheet provided in class to solve the problem. Show me sample calculations for both opening and closing cases so that I know that you can do such calculations by hand.

a) Calculate the arrival-departure saturation capacity diagram (Pareto diagram) under VMC 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 **two sample calculations** to obtain the values of Tij and Bij so that I can judge your analysis.

b) During a busy period of time, the airport is allowed to operate two arrival runways 19 (primary) and 15 (secondary runway). Calculate the new arrival-departure capacity diagram for this configuration. Assume that arrivals on runway 15 touchdown before intersection of runways 15 and 19. Hence wake vortex effect of arrivals on 15 does not affect departures on runway 19. Clearly state all your assumptions and human factor parameters used in the calculation.

Table 1. Airport Arrival Occupancy Times and Fleet Mix for Problem 1.

	Small	Large	B757
ROT (s)	40	51	55
Percent Mix	10	80	10
Vapproach (knc	110	145	150

Table 2. Minimum arrival-arrival separations under VMC conditions at DCA airport. Values in are nautical miles. Values Shown do Not Include Buffers.

Minimum Separation Matrix (nm)			Arrivals-Arrivals
		Trailing	
	Small	Large	B757
Small	2.5	2.5	2.5
Large	4.0	2.5	2.5
B757	5.0	4.0	2.5

Table 3. Estimated minimum departure-departure separations under VMC conditions at DCA Airport. Values in are seconds.

Departure-Departure Separation Matrix (seconds)			
		Trailing	
	Small	Large	B757
Small	55	55	55
Large	55	55	55
B757	90	75	75

Problem 2

Consider a variation of the problem for DCA airport. During North-flow operations, the airport operates as shown in the following diagram: a) Runway 1 used for both arrivals and departures, b) Runway 33 used to extend path of arrivals originally assigned to runway 1 allowing larger gaps on runway 1 for departures. An aircraft that is shifted from runway 1 to 33 using the side-step maneuver, increases the arrival time to the threshold over runway 33 by ~25 seconds.

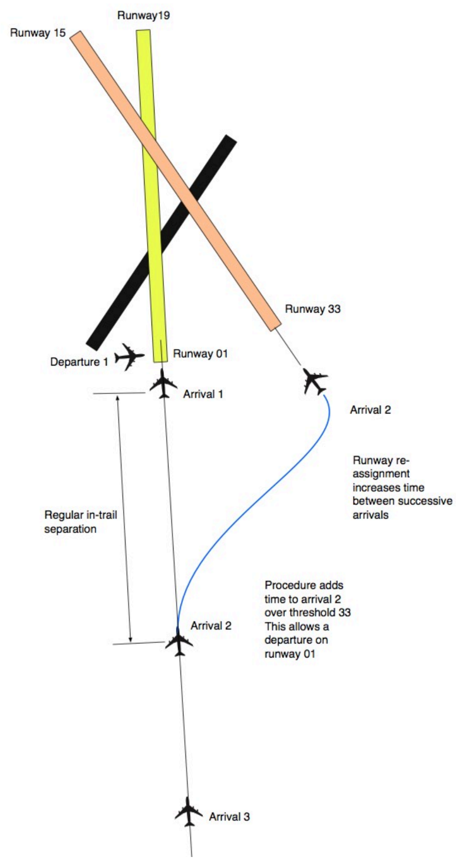

Figure 2. Operations at DCA Airport in North-flow Operations. Runway 1 used for Arrivals and Departures. Runway 33 Used for Side-stepped Arrivals.

a) Describe how would ATC use the side-step maneuver from runway 1 arrivals to runway 33 arrivals to improve the departure rate of runway 1.

b) Estimate the gaps (time between successive arrivals) that would be needed to make this procedure work.

Problem 3

Consider the Atlanta Jackson-Hartsfield International Airport described on pages 70-72 of the course notes (http://128.173.204.63/courses/cee4674/cee4674_pub/Capacity_Pareto_diagrams_Mult_runways.pdf). Consider two runways for this analysis: arrivals on runway 26R and departures on runway 26L. These runways are close parallel runways with a centerline distance of 1,000 feet. To solve this problem use the technical separations shown on pages 33 and 34 of the same handout. some Boeing 757 are handled as “heavy” aircraft.

The airport has the following technical parameters: a) in-trail delivery error of 15 seconds (because there is a radar at the site), b) 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 the table below.

a) During IMC conditions, ATC controllers will hold a departure on runway 26L if an approaching aircraft is within 1.5 miles distance from runway 26R to protect against a go-around operation on runway 26R and having a simultaneous departure on runway 26L. Estimate the reduction in departure capacity given the operating conditions.

b) Pot the Pareto diagram for the close parallel pair at ATL airport.

c) Plot the complete Pareto diagram for all 5 runways (assume runway 10-28 is only used for arrivals). Contrast your solution with the FAA numbers shown in the course notes.

	Small	Large	B757	Heavy	Superheavy
ROT (s)	45	52	55	57	75
Percent Mix (%)	2	79	12	7	0
Vapproach (knots)	109	139	143	154	150

Problem 4

Historical records for an airport show passenger boardings over time shown in Table 5.

a. Plot the historical number of total passenger enplanements as a function of time.

b. Estimate the best logistic model (i.e., estimate values of coefficients **a** and **b)** to fit the historical data and yet considering gate capacity limitations. The airport has **23 gate positions** and each one can handle 175,000 boardings per year.

c. Comment on the goodness of the logistic model vs. the data. Plot the historical data vs. the logistic curve obtained in step (b) to make meaningful comparisons.

d. Using this model predict when would the airport reach a point of 90% capacity?

Table 5. Caribbean Airport Demand

Year	Normalized Year	Passengers Boarding
1984	1	3,450
1985	2	7,100
1986	3	9,600
1987	4	12,897
1988	5	32,456
1989	6	51,300
1990	7	73,400
1991	8	70,800
1992	9	110,300
1993	10	166,300
1994	11	229,000
1995	12	345,000
1996	13	390,200
1997	14	451,200
1998	15	560,300
1999	16	652,000
2000	17	878,000
2001	18	934,000
2002	19	963,000
2003	20	1,234,000
2004	21	1,352,000

2005	22	1,450,000
2006	23	1,734,000
2007	24	1,785,447
2008	25	1,851,854
2009	26	1,894,292
2010	27	1,997,707
2011	28	2,225,657
2012	29	2,403,181
2013	30	2,597,086
2014	31	2,784,000
2015	32	3,178,000
2016	33	3,457,670