

Assignment 8: Airspace Capacity and Simulation Analysis

Date Due: April 4, 2018 (at the end of the day in my door)

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Problem 1

A single runway airport in the West Coast of the United States has a saturation capacity diagram as shown in Figure 1.

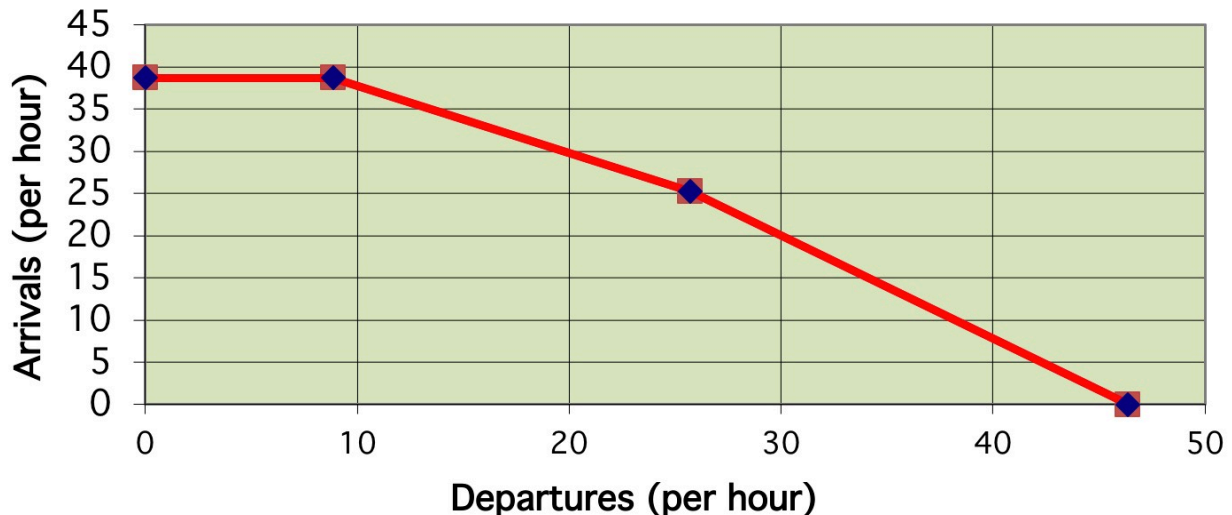


Figure 1. Arrival-Departure Diagram for Problem 1. Single Runway Airport. Points Along the Diagram are: (0,38), (9,38), (26,25) and (46,0) for departures/arrivals, respectively.

- Use the deterministic queueing model to estimate the average delays to both arrivals and departures at the airport if the daily demand function is as shown in Table 1. Solving this part of the problem assume the Air Traffic controllers at the airport like to operate at the 50/50 arrival/departure point in the capacity diagram shown in Figure 1.
- Estimate the maximum number of aircraft waiting for departure at the departure queue of the runway if the airport is operated at the 50/50 arrival/departure point in the capacity diagram.
- Improve the solution found in part(a) and recommend operating points along the capacity diagram boundary during certain periods of time to minimize total cost of delays. because changes in arrival/departure patters involve ATC coordination, you are allowed to select up to four operating points during the 24 hour period. For example, during 3 hours of the day the airport could be operated at point (26,25). For another 4 hour period it could be operated at another point along the boundary, etc. The cost of delays for each arrival is \$3,700 whereas the cost for departures is \$1,800 per hour. Compare the cost of delay of your solution with the solution obtained in part (a).
- For the best solution found in part (c) estimate the average delay for arrivals and for departures.
- Why is the cost of arrival delays more than departures.

Table 1. Flight Demand for Problem 1. Demand Values are Per Hour.

Time Period (Bin Center)	Arrival/hr	Departures /hr	Total Operations/hr
0.5	2	0	2
1.5	3	1	4
2.5	5	3	8
3.5	6	4	10
4.5	8	10	18
5.5	16	7	23
6.5	30	20	50
7.5	31	25	56
8.5	15	31	46
9.5	27	17	44
10.5	30	26	56
11.5	17	28	45
12.5	21	14	35
13.5	23	22	45
14.5	29	19	48
15.5	33	28	61
16.5	10	32	42
17.5	18	13	31
18.5	15	19	34
19.5	14	16	30
20.5	32	21	53
21.5	15	30	45
22.5	8	16	24
23.5	2	6	8
Totals	410	408	818

Problem 2

Data is collected at an airport for two aircraft 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. If one parameter is given assume the value is deterministic.

Parameter	Boeing 737-800	Bombardier Q400
Touchdown distance (m)	$dt=(385,109)$	$dt=(319,97)$
Approach speed (m/s) - at threshold	$V_{app} = (71.5,3.1)$	$V_{app} = (58,3.3)$
Free roll time (seconds) - time to start applying brakes and thrust reverser	$tr = (4.5,0.5)$	$tr = (4.3, 0.6)$
Deceleration rate (m/s-s)	$a_{Mean}^1 = (2.2,0.42)$	$a_{Mean} = (2.1,0.34)$
Exit Speed (m/s) (high-speed exit)	$V_{exit} = (22)$	$V_{exit} = (22)$

1 - deceleration rate is negative in the equations on handout so here we show the values as positive.

- a) Using Matlab or Excel (your choice), and the kinematic equations of motion shown on the course 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 the landing distances to reach a high-speed exit point (i.e., point on the runway where the aircraft reaches the exit speed shown in Table 2). **This analysis requires a simple Monte Carlo simulation.** Assume each aircraft represents 50% of the population operating at the airport (i.e., only two aircraft operating at the airport).
- b) Plot the distributions of the landing distances for both aircraft (either PDF or CDF).
- c) Where would you locate 3 high-speed runway exits if the airport has a single 3100 meter runway? State the distances from the threshold of your suggested high-speed runway exits. State your rationale for locating the 3 high-speed runway exits. Assume that a fourth runway exit (90 degree turnoff) will be located at the end of the runway.