CEE 5614: Analysis of Air Transportation Systems Fall 2018

Assignment 7: Airport Capacity

Date Due: November 26, 2018 Instructor: Trani

Problem 1

A single runway airport has a saturation arrival-departure capacity diagram (Pareto diagram) as shown in Figure 1.

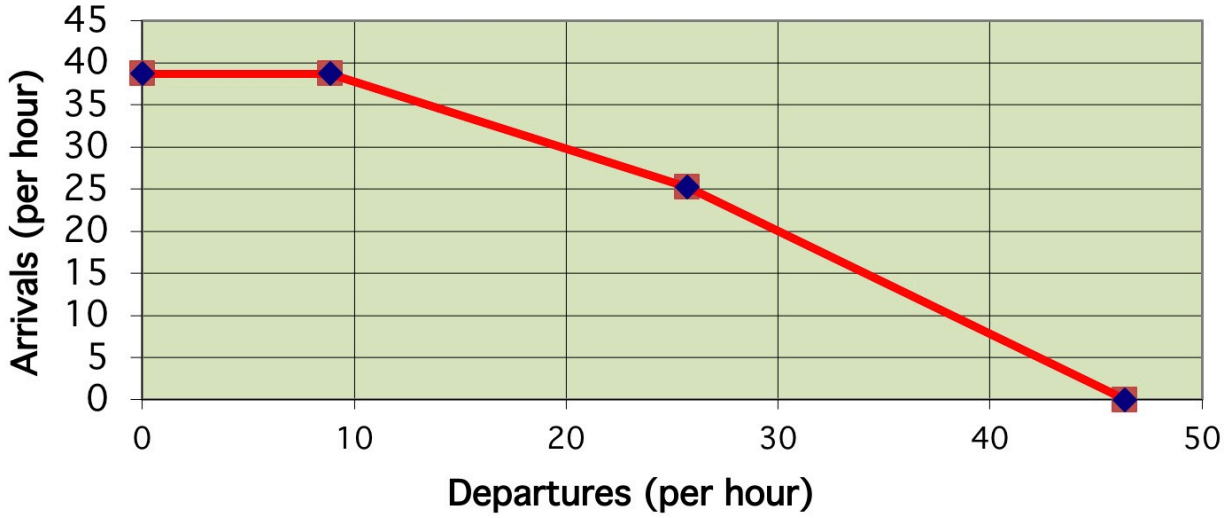

Figure 1. Arrival-Departure Diagram for Problem 1. Single Runway Airport. Points Along the Diagram are: (0,38), (9,38), (26,25) and (46,0) for departures/arrivals, respectively.

a) 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 (i.e., 50% arrivals and 50% departures) in the capacity diagram shown in Figure 1.

b) Estimate the average delay to departing aircraft at the departure queue of the runway if the airport is operated at the 50/50 arrival/departure point in the capacity diagram.

c) Estimate the average delay to arriving aircraft if the airport is operated at the 50/50 arrival/ departure point in the capacity diagram.

d) The cost of delays for each arrival is $4,700 whereas the cost for departures is $2,600 per hour. Estimate the cost of delay obtained in parts b and c.

e) 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 three operating points during the 24 hour period. For example, during 4 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.

f) For the best solution found in part (e) estimate the average delay for arrivals and for departures.

g) Why is the cost of arrival delays more than departures. Explain.

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	28	20	48
7.5	28	25	53
8.5	15	29	44
9.5	27	17	44
10.5	28	25	53
11.5	17	27	44
12.5	21	19	40
13.5	23	22	45
14.5	29	19	48
15.5	19	28	47
16.5	10	30	40
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	389	407	796

Problem 2

Review the runway configuration of México City airport (see Figure 2 and consult Google Earth if necessary). Runway 5L is normally used for departures. Runway 5R is used for arrivals. Because the close proximity of the runways, ATC controllers **"block"** departures on runway 5L when an arrival is inside the **"reserved zone"** in Figure 3 to reduce the risk of a simultaneous go-around on runway 5R and a departure on 5L in close parallel operations. Aircraft in "line and wait position" are clear to depart once the arrival is outside the reserved zone (either more than 1.4 nm from the threshold or just over the threshold). Table 1 shows the fleet mix for México City. Figure 4 shows the standard ICAO separations applicable to México City (IMC conditions). Table 2 shows the typical departure-departure separations used in México City. Mexico has standard airport surveillance radar. The common approach length is 10 nm. Use a probability of violation of 5%. The ATC controllers are conservative and use an in-trail position error of 20 seconds.

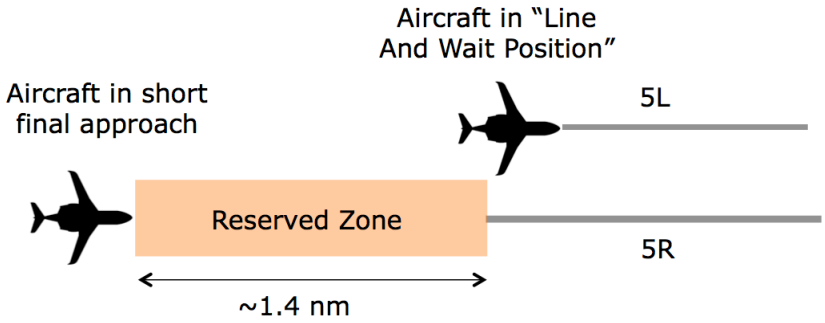

Figure 2. Close Parallel Configuration of Mexico City Airport.

Table 1. Runway Operational Parameters and Fleet Mix for México City Airport.

Aircraft	Percent Mix (%)	Runway Occupancy Time (s)	Typical Approach Speed (knots) from Final Approach Fix
Small	4	50	126
Large	72	54	146
Heavy	22	61	161
Superheavy	2	76	158
Totals	100		

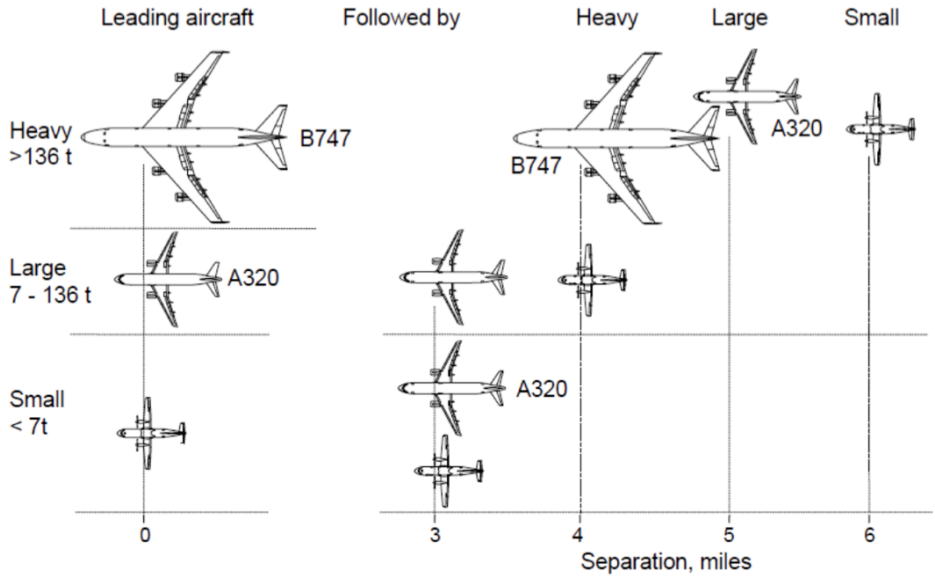

Figure 4. ICAO Recommended IMC Separations. Source: Lang et al., 2010. Arrival-Arrival Separations.

Table 2. Minimum Departure-Departure Separations Observed in Mexico City. Columns are the Following Aircraft. Values in are seconds.

Aircraft	Small	Large	Heavy	Superheavy
Small	75	75	90	90
Large	70	70	70	70
Heavy	120	120	120	120
Superheavy	180	120	120	120

a) Find the IMC capacity diagram for this airport. Clearly explain how do you account for the dependency between arrivals and departures in your solution.
b) Plot the Pareto diagram for the two runways operated in IMC condition.
c) A new airport in Mexico City will open in the year 2023. The new airport will have two parallel runways located 1700 meters away from each other. Find the capacity of the new airport if one runway is used for arrivals and one for departures.