CEE 5614: Analysis of Air Transportation Systems Spring 2023

Final Project

Date Due: May 8, 2023 by Midnight Instructor: Trani

Rules:

Groups of 2 students allowed if solving both problems
If you work individually, **select one problem**
Include a brief writeup of the answers and explain your solution
Include the Excel or Matlab file used to solve the problem
Send me the Excel or Matlab scripts for review
Include VT Honor Code Pledge

Problem 1

An airport has a runway configuration and saturation capacity diagram as shown in Figures 1 and 2, respectively. The airport operates in segregated mode for safety (one runway for arrivals and one for departures).

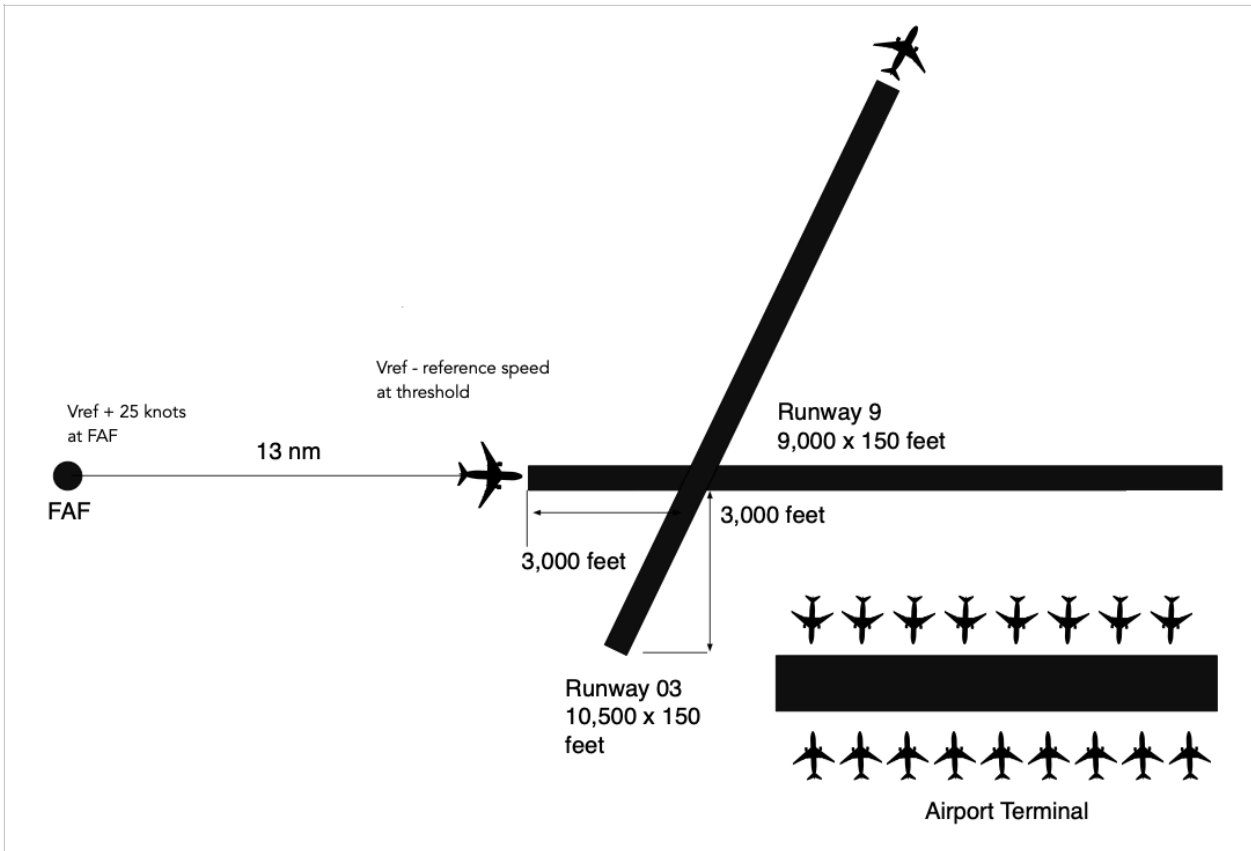

Figure 1. Runway Configuration and Arrival-Departure Diagram for Problem 1.

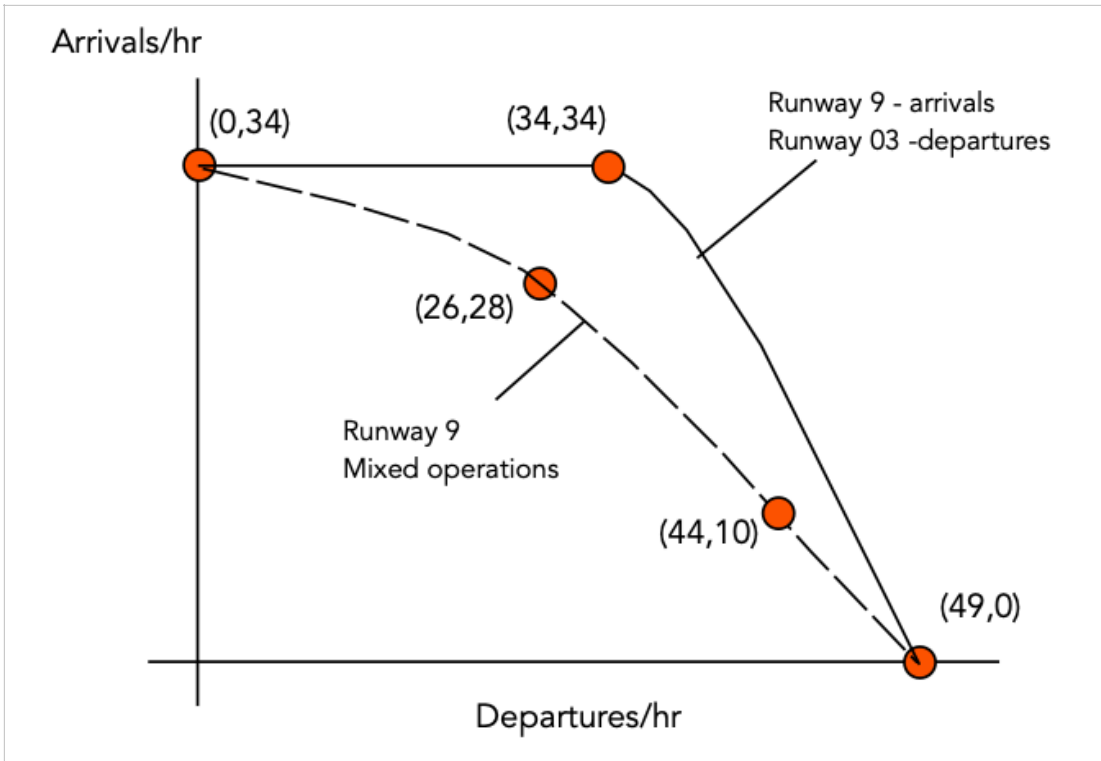

Figure 2. IMC Runway Capacity Diagram for One and Two Runway Operations for Runway Configuration of Figure 1.

a) Table 2 shows the daily demand function for arrival and departures at the airport. Use the **deterministic queueing model** to estimate the **average delays per flight delayed** to both arrivals and departures at the airport. Consider that air traffic controllers organize the traffic from an initial far-away fix to the FAF (final approach fix) to control the arrival separation and hence regulate the operational point along boundary the Pareto diagram (arrival-departure diagram). In a given day, no more than three distinct points on the Pareto boundary can be achieved because it takes time to reconfigure the separations between arrivals. In your calculations, tell me the operating point selected on the Pareto frontier of the arrival-departure diagram.

b) Estimate the annual cost of delay to airlines if the hourly cost of for an arrival is $6,800/hr and the hourly cost of departures is $4,400/hr. Assume the airport has daily operations similar to Table 1 for 365 days a year.

c) Estimate the annual cost of delay to passengers if the value of time for a passenger is $39/hr. The average passengers per flight at the airport is 141 passengers (typical in the United States).

d) A third runway has been planned for the year 2029 to the South of runway 9. The airport authority expect demand to growth at 3.5% per year for the next ten years. Would you recommend the third runway based on the analysis done and extrapolating the future delays?

e) If a third runway is built state what is the recommended separation between the existing runway 9 and the new parallel runway. Assume PRM and ADS-B (one second) position data technology is available to the project.

f) How would you recommend the third runway be operated at the airport? Be specific about your recommendation. For example, will the third runway serve arrivals and departures or just arrivals. Explain your rationale with numerical values and calculations.

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

Time Period (Bin Center)	Arrivals/hr	Departures /hr	Total Operations/hr
0.5	3	4	7
1.5	5	4	9
2.5	10	8	18
3.5	15	4	19
4.5	18	15	33
5.5	22	26	48
6.5	35	31	66
7.5	38	33	71
8.5	36	36	72
9.5	31	38	69
10.5	30	36	66
11.5	19	28	47
12.5	21	14	35
13.5	28	22	50
14.5	35	19	54
15.5	36	24	60
16.5	20	32	52
17.5	18	36	54
18.5	32	40	72
19.5	38	38	76
20.5	35	41	76
21.5	30	34	64
22.5	15	18	33
23.5	2	6	8
Totals	572	587	1159

Problem 2

Solve an updated version of the Airline Scheduling Problem (ASP-1) explained in class with the following characteristics. The airline is evaluating the purchase of new generation regional aircraft (i.e., Transonic Truss-Braced Aircraft - TTBA) to operate out of DCA. The new airline wants to operate in the markets shown in Table 3. The following aircraft are potential contenders for possible use by the airline.

a) Maximize profit solving for the fleet size and frequency assignment **without a minimum frequency constraint**. Clearly state the number of aircraft of each type needed (use an **integer solution if desired to make the problem more realistic**) and the number of flights between each origin-destination pair to satisfy the two basic constraints (demand and supply constraints). Use Excel Solver to solve the problem.

b) Calculate the fares to be charged in each O-D pair if the airline wants to recover its full cost for service plus a 10% profit. In your calculation assume the hourly operating cost of the aircraft shown in Table 2 is 75% of the total operating cost of the carrier. That is, 25% of the cost of running is due to administrative and other costs not related to operation of the aircraft.

c) Comment your assessment of the economics of using new generation TTBA in the proposed routes.

All other parameters of the model are the same as ASP-1.

Table 2. Aircraft Operating Cost and Performance.

Aircraft	TTBA	Boeing 737-700	Airbus A319
Seats	128	132	130
Block Speed (knots) Gate-to-Gate	390	400	395

Aircraft	TTBA	Boeing 737-700	Airbus A319
Operating Cost ($/hr)	4,500	5,800	5,900
Typical maximum aircraft utilization (hrs/day) in service	12.0	13.0	13.0

Table 3. OD Markets for the Proposed New Airline.

Origin-Destination Airports	Daily Demand (passengers)
DCA-ATL	620
ATL-DCA	600
DCA-BOS	430
BOS-DCA	440
DCA-DFW	230
DFW-DCA	200
DCA-LGA	400
LGA-DCA	420